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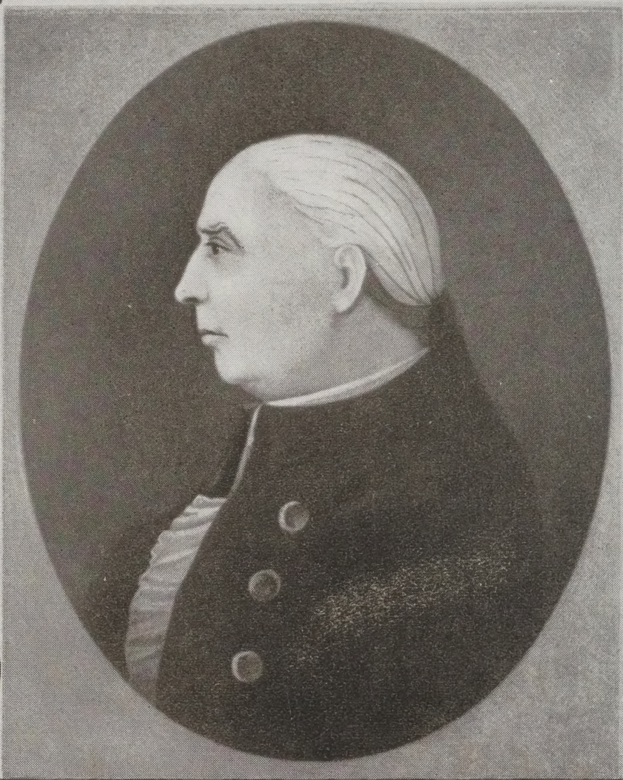

BRIG. GEN. RUFUS. PUTNAM
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CONSTRUCTION OF RUBBLE MOUND EXTENSION TO BREAKWATER AT MARQUETTE, MICH.

By

Mr. Clarence Coleman

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Marquette Harbor in Marquette Bay is on the south shore of Lake Superior, 158 miles west of Sault Ste. Marie, Mich., and 258 miles east from Duluth, Minn. (See Plate I.)

Its improvement by the United States was commenced in 1867, and contemplated a breakwater of crib construction with rock filling extending out from the shore in a southerly direction for a distance of 2,000 feet. Provision was made in 1888 by Congress for an additional extension of 1,000 feet of stone-filled cribs on a rubble mound embankment, and the breakwater was completed to a total length of 3,000 feet in 1894.

In 1890 the older portion of the superstructure showed considerable decay, and a project for surmounting 2,000 feet from the shore eastward with a concrete superstructure was approved by the Chief of Engineers. This estimate was again increased in 1891 to cover the entire length of 3,000 feet with a concrete superstructure. Work was commenced upon this in 1895, and the concrete superstructure was completed for a length of 2,920 feet in 1905. A further modification of the project was made by the Rivers and Harbors Act of June 25, 1910, which provided for the construction of an extension of 1,500 feet in a southeasterly direction and for the removal of a shoal in the northerly part of the harbor, giving a protected area of 350 acres.

The proposed extension of 1,500 feet consisted of stone-filled cribs 24 feet deep and 30 feet wide resting upon a rubble mound foundation and the whole length surmounted with a concrete superstructure rising to 10 feet above the top of the crib and 11 feet above low water datum.

With a view to carrying out this design, work was commenced upon the rubble mound embankment for the crib foundation in 1911

and completed in October, 1913, with a total of 92,880 tons of stone at a total contract cost of $109,206.21, or an average cost of $1.175 per ton for the three separate contracts under which the work was performed. In 1914, after a thorough study of the proposed crib construction with concrete superstructure, and due consideration of the very exposed condition of this harbor, as well as further economic reasons, the Chief of Engineers on August 21, 1914, authorized a change of type from the stone-filled crib substructure with concrete superstructure to a rubble mound breakwater extension.

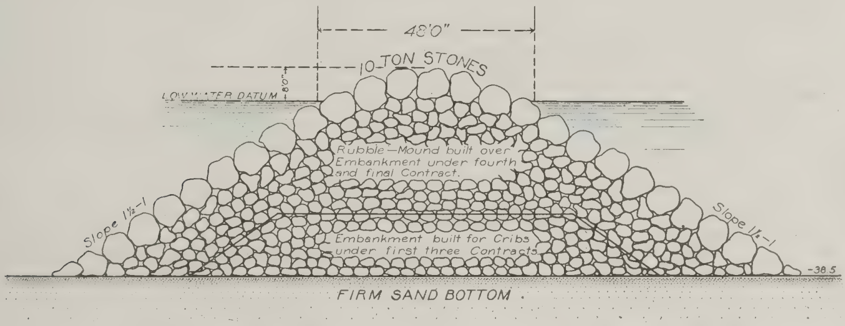
A design was submitted and approved, as shown on Plate II. The specification provided for a cross-section with a width of 48 feet at low water datum, with a slope on both lake and harbor sides of 1 foot vertical to 1½ feet horizontal. The cross-section from low water datum to the crown of the mound to be defined by a curve with a radius of 40 feet, rising to 8 feet above datum at the crown, each end of the breakwater covered by these specifications to be finished by extension in such a manner that all radial half sections originating in the vertical axis of the normal end section shall be practically the same as the half cross-section of the structure; the intent being that the side slopes shall be carried around the end in approximately a conical form. The breakwater to consist of a core of rock of varying sizes limited to a minimum of 100 pounds for any single piece. The covering stones are limited to a minimum weight of 10 tons, and stones exceeding 15 tons are not desirable.

Method of Placing Stone. Stones used for building the core may be dropped or dumped into the water, but stones used for covering shall be set in place before being released, unless, in the judgment of the contracting officer, they can be dropped to place without detriment to the work. The stone shall be placed within certain lines to be established by ranges. The core and the covering stone shall be built up together, the core being kept very slightly in advance of the covering stone in vertical height. The covering stone shall, as nearly as the shape of that stone will permit, cover the breakwater core from the lake bottom upward on the grade or limit line shown on the drawing. All covering stone shall be firmly set and well supported on the underlying stone and the interstices between contiguous stones reduced to a minimum for this class of work. The contracting officer shall be the sole judge as to the placing of all stone in this work.

The first course of covering stone at foot of slopes shall be kept

not less than 100 feet in advance of any core stone except toward the close of the working season, when the core will be advanced and all brought to the required cross-section to allow for covering the uncompleted end with the 10-ton stones for protection until the work is again resumed. No core stone will be accepted or paid for that is more than 250 feet in advance of the completed section.

The stone used in this work must be of igneous origin and shall weigh not less than 165 pounds per cubic foot. Samples of the stone which the bidder proposes to use shall be submitted to this office with transportation prepaid at least 10 days before the bids



MEAN CROSS-SECTION OF RUBBLE-MOUND EXTENSION.
Scale
10 5 0 10 20 30 40 50 FT.

CONSTRUCTION OF
RUBBLE – MOUND EXTENSION
TO BREAKWATER.
MARQUETTE, MICH.
1917

are opened. The least dimension of any covering stone shall be not less than one-fourth of its greatest dimension.

Measurement. Stone will be paid for by the ton of 2,000 pounds in place in the work, as determined by water displacement, allowing 62½ pounds for 1 cubic foot of water. The vessels containing the stone shall be fitted by the contractor at his own expense with standpipes, water tubes and graduated rules, or such other facilities for determining their displacement as may be required by or be satisfactory to the contracting officer. Before vessels deliver stone their water displacement for various load depths shall be accurately determined, either from actual measurement of their cubic contents or by accurately "weighing in" with stone of known weight; and the displacement for various load depths shall be distinctly marked or otherwise recorded. This "weighing in" and marking shall be done under the supervision of the contracting officer or his repre-

sentative, and all cost thereof shall be paid by the contractor. Vessels, which, owing to their model or other cause, can not be accurately gauged for displacement will not be accepted or "weighed in."

In "weighing in," the vessel must be kept in the same fore and aft trim that is used in freighting stone. When the fore and aft readings of the loaded vessel differ by more than 10 per cent of their mean, the contractor shall trim the vessel by shifting the stone until this limit is reached before the stone will be received. The United States inspector will, before any part of the stone is unloaded, ascertain the displacement by means of the load-depth marks, and again after the stone is all discharged. The amount of stone will be determined from these displacements.

All measurements for "weighing in" and for load depths shall be made in still water, as close to the work as is possible, and the contractor will be required to place the vessels where such measurement can be accurately made.

Lighterage by pumping or by transfer of crews or supplies will not be permitted while stone is being discharged. Should any lighterage become necessary, the unloading of stone shall be suspended and the load marks be taken in such manner as to insure the United States against loss from that cause.

In case any stone is delivered by vessels not "weighed in" and marked as hereinbefore provided, the contractor shall, at his own expense, furnish means for properly and conveniently weighing such stone at the work.

Proposals were received for completing this work on October 23, 1914. The lowest and accepted bid was $1.10 per ton for stone in place in the breakwater. The estimate for completing the 1,500 feet of rubble mound extension to breakwater as provided in the specifications and as shown herein was based on the dimensions stated therein and on the actual weight of the stone determined as 167.7 pounds per cubic foot, with a deduction of 45 per cent for voids and an addition of 8 per cent for settlement.

A total of 92,880 tons had already been placed under the three preceding contracts as an embankment for the cribs, which plan was afterwards superseded by the rubble mound construction.

The following shows the method used in estimating quantities and cost:

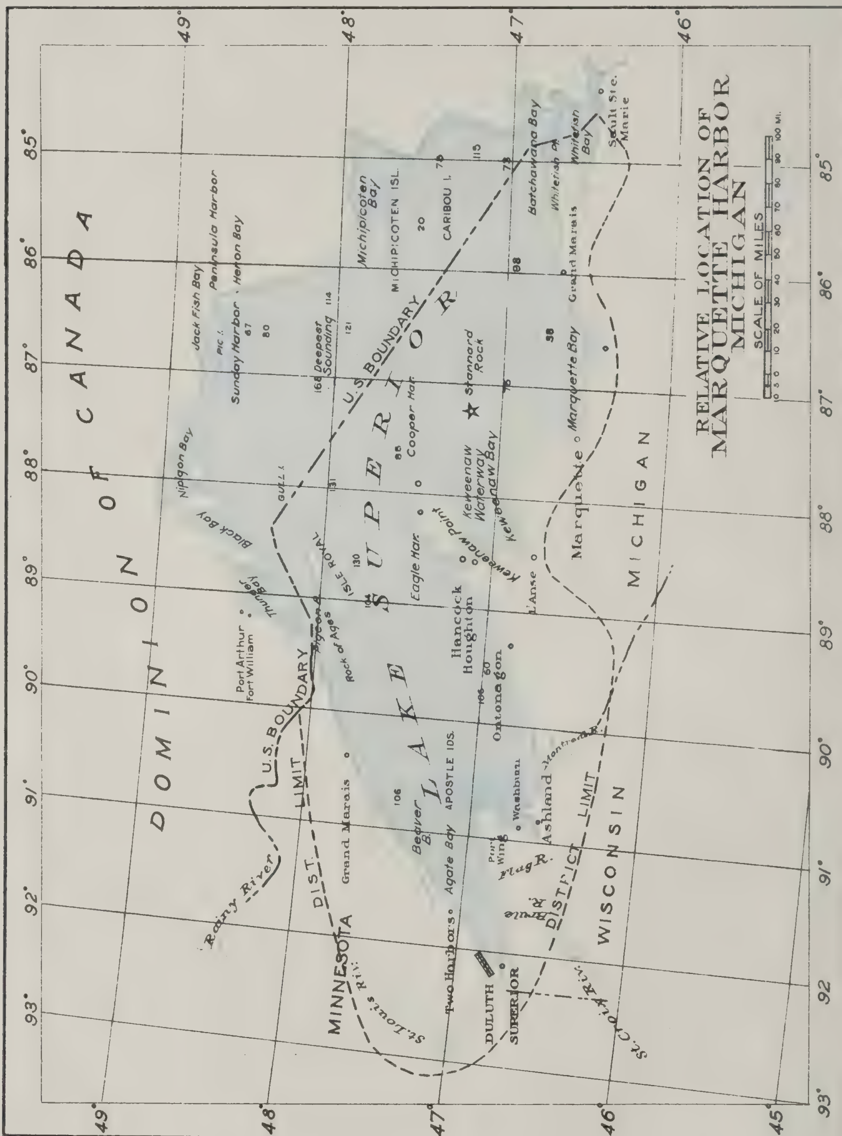
Area of mean section .... square feet		4,332.864
Length of breakwater .... linear feet		1,500
Total volume of breakwater considered as a solid, including end slopes	6,731,445	
Less cubic feet in solidity already placed	1,770,660	
Total cubic feet in solidity to complete 1,500 feet		4,960,785
Cubic feet of solids after deducting 45 per cent for voids		2,728,431
Total tons for 1,500 feet of breakwater at 167.7 pounds per cubic foot	228,778	
Add 8 per cent for settlement	18,302	
Total tons required to complete 1,500 feet of breakwater		247,080
Estimated cost per ton in place at $1.25 per ton	$308,850	
Add 20 per cent for administration and contingencies	61,770	
Total cost for rock in breakwater		$370,620
Add for concrete filling between stones at outer end		1,000
Total cost to complete 1,500 feet breakwater extension		$371,620
Amount of money authorized to complete		$382,000
Cost to complete		371,620
Balance		$10,380

As before stated, a total of 92,880 tons of stone was placed under three contracts for the rubble mound embankment which was to have served as a foundation for the proposed cribs with concrete superstructure. The work under fourth and final contract for the conversion from the crib type to the purely rubble mound type was commenced on April 28, 1915, and completed on July 25, 1917.

The total amount of stone placed and paid for under the four contracts was 347,824 tons; of this amount 5,805 tons were placed at the connection of the crib breakwater with the rubble mound and 1,900 tons along the re-entrant angle on the lakeside formed by junction of the two different types of breakwaters.

This combined amount of 7,705 tons being outside of the prism upon which the original estimate was based, will for the sake of comparison be eliminated from the totals in the analysis which follows.

Considering first the amount of stone placed in the embankment


RELATIVE LOCATION OF
MARQUETTE HARBOR
MICHIGAN
SCALE OF MILES
DOMINION OF CANADA
LAKE SUPERIOR
MINNESOTA
WISCONSIN
MICHIGAN
U.S. BOUNDARY
DIST. LIMIT
DISTRICT LIMIT
Marquette
Marquette Bay
Grand Marais
Sault Ste. Marie
Whitefish Bay
Batchawana Bay
Michipicoten Bay
MICHIPICOTEN ISL.
CARIBOU I.
Stannard Rock
Keweenaw Bay
Keweenaw Waterway
Hancock
Houghton
L'Anse
Ontonagon
Ashland
Washburn
Port Wing
APOSTLE IDS.
Beaver B.
Agate Bay
Two Harbors
DULUTH
SUPERIOR
Grand Marais
Rock of Ages
ISLE ROYAL
Eagle Har.
Cooper Har.
Deepest Sounding
Port Arthur
Fort William
Thunder Bay
Black Bay
Nipigon Bay
Sunday Harbor
Jack Fish Bay
Peninsula Harbor
Heron Bay
Rainy River
St. Louis Riv.
St. Croix Riv.
Montreal R.
Flag R.
Brule R.

under the three first contracts, and given in the original estimate as representing a volume of 1,770,660 cubic feet with weight determined as 167.7 pounds per cubic foot would give for voids:

$\frac{1,770,660 \times 167.7}{2,000}=148,469$ tons for the 1,500 feet of embankment considered as a solid. The actual tons placed to complete the embankment was 92,880. Hence $\frac{92,880}{148,469}=62.57$ per cent of solid stone=37.43 per cent of voids.

Under the fourth and final contract which provides for building the rubble mound extension and under which the work was completed, the original estimate shows a total volume for 1,500 feet of rubble mound as 6,731,445 cubic feet, from which deducting 1,770,660 cubic feet for work previously done gives 4,960,785, all as shown in the orginal estimate.

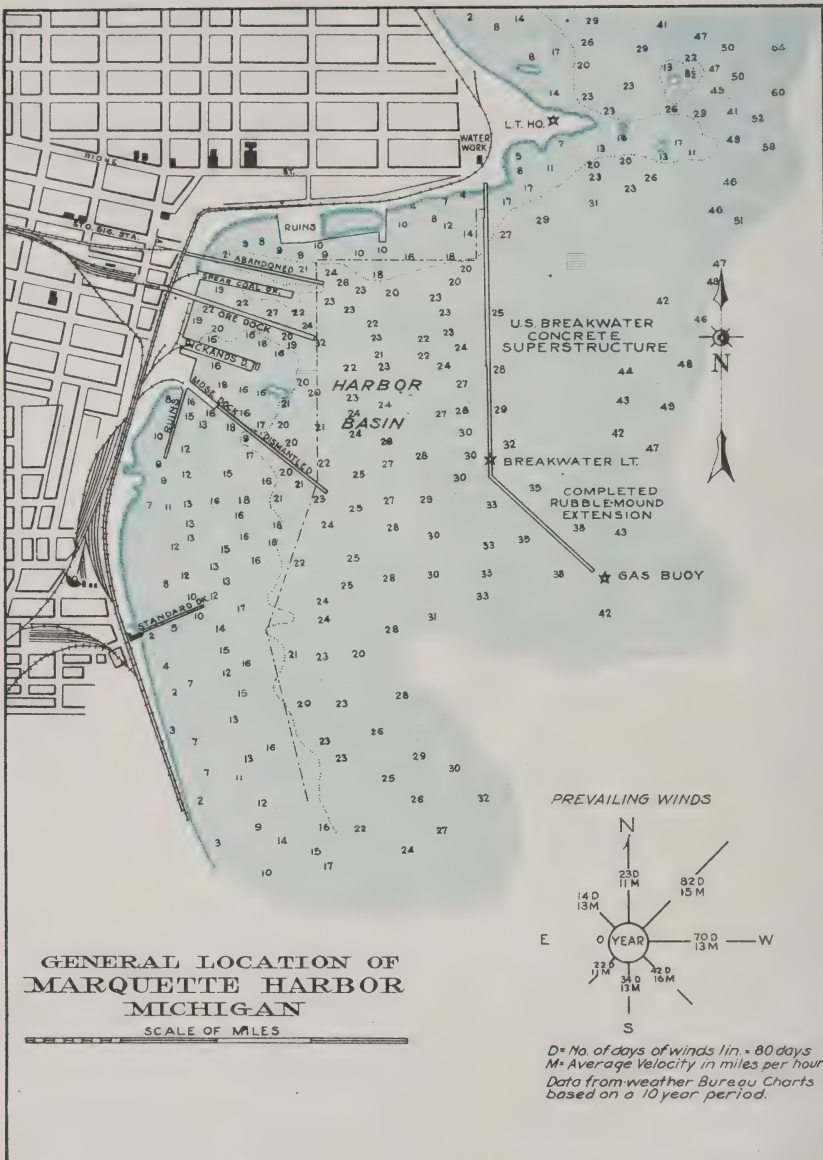
The total tons placed and paid for under this final contract was 254,944. Deducting from this amount the 7,705 tons placed outside of the cross-section upon which original estimate was based, gives 247,239 tons as the amount to be considered in comparing actual results with the estimate.

Then $\frac{4,960,785 \times 167}{2,000}=415,961$ tons for the solid volume of the rubble mound extension built over the breakwater embankment. However, the actual tons placed and paid for within the prescribed cross-section was 247,239 tons.

Hence, $\frac{247,239}{415,961}=59.43$ per cent of solid stone=40.57 per cent voids. From the above, it will be seen that the actual results on the final contract show an increase of 159 tons over the original estimate and a decrease of 4.43 per cent on the estimate for voids.

The very close approximation of the actual tonnage in the completed contract to that of the original estimate, seems to indicate that the allowance of 8 per cent for settlement is substantially correct, and the small reduction in voids most likely due to the partial closure of interstitial space caused by the process of settling. The lake bottom along the site of the breakwater consists of fine hard packed sand with a very small percentage of gravel.

For the total and unit contract cost of the completed 1,500 feet of rubble mound breakwater, considering only the stone which was


GENERAL LOCATION OF
MARQUETTE HARBOR
MICHIGAN
SCALE OF MILES
U.S. BREAKWATER
CONCRETE
SUPERSTRUCTURE
BREAKWATER LT.
COMPLETED
RUBBLE-MOUND
EXTENSION
GAS BUOY
HARBOR
BASIN
L.T. HO.
WATER WORK
RUINS
ABANDONED
SPEAR COAL BR.
ORE DOCK
PICKANDS D.
MOSE DOCK DISMANTLED
STANDARD DK.
RIDGE
ST.
STD. SIG. STA.
N
PREVAILING WINDS
N
E
W
S
YEAR
23 D
11 M
82 D
15 M
14 D
13 M
0
70 D
13 M
22 D
11 M
34 D
13 M
42 D
16 M
D= No. of days of winds 1in. = 80 days
M= Average Velocity in miles per hour
Data from weather Bureau Charts
based on a 10 year period.

placed within the adopted cross-section: the stone in the embankment, 92,880 tons plus the stone in the rubble mound 247,239 tons=340,119 tons of stone in the completed breakwater. The stone in embankment cost $109,206.21, and the stone in rubble mound cost $271,962.90, making a total contract cost of $381,169.11.

$\frac{\$381,169.11}{\$340,119}$=$1.1206 per ton, or average contract cost for entire rubble mound breakwater.

In a like manner, dividing $381,169.11 by 1500 gives $254.11 as the contract cost per linear foot of the breakwater, without inspection and administration.

Considering, further, the additional cost of the work comprised in the cross-section of the rubble mound breakwater for its full length of 1,500 feet under all four contracts for inspection and office administration.

Total tons placed 347,824, less 7,705 tons placed outside	340,119@$1.1206 =	$381,169.11
Inspection	340,119@ 0.0295 =	10,018.18
Administration	340,119@ 0.11206=	38.116.91
Total cost for entire work in cross section	=	$429,304.20

Unit costs, 1.10+0.0295+0.11206=$1.26216 per ton.

$\frac{429,304.20}{1,500}$=$286.20. Total cost, per linear foot, of the completed rubble-mound extension.

For the purpose of instituting a comparison with the original estimate for the rubble mound breakwater built over the embankment under the fourth contract, and proceeding in the same manner:

Total tons placed 254,944, less 7,705 tons placed outside cross section	247,239 tons@$1.10 =	$271,962.90
Inspection	247,239 tons@ 0.0253=	6,244.43
Administration	247,239 tons@ 0.110 =	27,196.29
Total cost under fourth contract	=	$305,403.62

Unit costs, 1.10+0.0253+0.110=$1.2352 per ton.

Comparing the figures for the fourth and final contract, as shown above, with the original estimate for the same, it will be seen that the original estimate of cost was $371,620, from which

$1,000 estimated for concrete and omitted from the work should be deducted, giving a final result, $370,620. $305,403.62=$65,216.38, which represents the difference in actual and estimated cost.

Finally, a comparison will be made to show the relative economy of the rubble mound breakwater as constructed to the type of crib breakwater with concrete superstructure with a rubble embankment foundation, which was originally selected and recommended for the 1,500-foot breakwater extension in Marquette Harbor. A detailed estimate for this breakwater is shown in paragraphs 18 and 19, House Document No. 573, 61st Congress 2nd session. The total estimated cost of this type for 1,500 feet is shown as $461,500. The total actual cost of the completed rubble mound breakwater for the same length, as before given in this article, is $429,304.20, or an economy of $32,195.80, or of $286.20 per linear foot as against $307.66 per linear foot in favor of the rubble mound type. The relative permanence and stability undoubtedly resides largely with the rubble mound when constructed with the quality and weight of stone used at Marquette.

In the same House Document, Type 4 includes an estimate for a rubble mound breakwater with slopes of 1½ to 1 as in the Marquette breakwater, but of larger cross-section. The estimate given for 1,500 linear feet of the type 4 is $771,360; which would equal a cost of $514.24 per linear foot as against a total cost for the breakwater as built of $429,304.20, or $286.20 per linear foot for actual cost.

This shows an economy in the type adopted and built over type 4, as proposed, of a total of $342,056, or a saving of $228.04 per linear foot.

If the unit costs of the estimate for type 4 are applied in the case of the completed breakwater, the result is 340,119 tons×$1.50= $510,178.50, to which add 20 per cent for administration and contingencies, making a total cost of $612,214.20. $612,214.20— $429,304.20=$182,910, which represents the saving in cost of the completed breakwater, had it been built, at the estimated costs as shown for type 4.

Under the fourth and final contract, which embraced the building of the rubble mound over the embankment already built as foundation for proposed cribs, the contractor received $1.10 per ton of 2,000 pounds for rock of all specified classes in place in the

Fig. 1. View on lake side, showing arrangement of paddle ranges.

Fig. 2. View showing two floating derricks setting the large covering stone.

breakwater. The equipment for this class of work was exceptionally good.

A large portion of the rock used was from Middle Island, 5⅔ miles distant from the work, where the contractor assembled a very complete quarry equipment consisting of locomotives, cars, steam shovels, power drills, etc., 30-ton locomotive crane, a loading dock for loading rock of the smaller dimensions into dump scows, shops with drill-shaping machines. It is estimated that about 75 per cent of the large covering stones was obtained from the lake shore and bottom

Fig. 3. Derrick scow *Jupiter* setting large covering stone on lake side slope of the substructure.

as boulders, the latter class being grappled with the aid of a diver. For transportation and placing stone two large derrick scows with booms of 77 and 72 feet length, equipped with heavy manganese steel grapples having a capacity of handling stones up to 40 tons in weight, and a carrying capacity of from 300 to 600 tons were provided. Two steam tugs and one gasoline tug handled the scows. The number of men employed varied from 90 to 130 of all classes. The core of the breakwater was placed largely from dump scows. These scows, with a capacity of 350 tons, were loaded at the quarry

dock by means of strongly constructed chutes which greatly facilitated the loading process. At the breakwater site the stations were determined by buoys and by permanent marks on the breakwater, as it was extended outward and the positions of the courses of stone were determined by ranges of three kinds, viz: fixed, firmly anchored floating ranges, and suspended or paddle ranges. It is usual to suspend paddle ranges from a wire rope stretched trans-

Fig. 4. Setting the large covering stone in the superstructure.

versely across the breakwater and supported by piles driven on each side, but in this case the depth of water and exposure to storms on the lake side precluded this method. To carry into effect this character of ranges, a mast was erected on the center line of the breakwater and securely guyed. To this mast a 3-inch pipe was firmly attached and guyed, from which the paddle ranges were suspended. Fig. 1. For placing the covering stone of 10 tons weight or more, the large derrick scows were used and a diver constantly attended the proper placing of these stones under water.

The procedure was to first place the large stone at the foot of

the slope to hold and prevent the core from spreading beyond the foot of slope line, and then to carry the work upward as rapidly as the core was built to the proper cross-section to receive and support the covering stone. Fig. 2 is a view looking lakeward from the outer end of the concrete breakwater and shows the two large floating derricks engaged in setting covering stone on both sides of the breakwater. Fig. 3 is a view looking shoreward and shows the derrick scow *Jupiter* setting covering stone in place below the

Fig. 5. Setting large covering stone in the superstructure.

water. To the left may be seen the anchored floating ranges and the distant rear ranges at the shore. The process of setting the covering stone in the superstructure is well illustrated in Figs. 4 and 5.

Fig. 6 shows an elevation of a completed part of the breakwater extension, and shows also the irregular shape of the stone used in its construction. Stone of the class shown is believed by the author to give the greatest possible efficiency to be obtained in rubble mound breakwater construction, as the stones by reason of their very

irregular and angular shapes are not interdependent upon each other as when they are of more symmetrical form and laid up in courses in such a manner as to present a more regular exterior surface.

This method of construction has been adopted in this district, at the Superior Entry and Marquette. Both of these localities are rigorous exposures to the severe northeast storms, often accompanied with heavy icebergs that frequently prevail on this lake. These structures have proved their ability to withstand the storm forces in a very marked and satisfactory manner; and experience

Fig. 6. Elevation of part of completed breakwater, looking lakeward.

seems to indicate that the cost of maintenance will be almost a negligible factor.

Fig. 7 is a view along the lake side of the rubble mound, showing about 1,115 linear feet of completed rubble mound. Note also some of the range marks painted in white upon the concrete superstructure of the older breakwater. This view also illustrates very clearly the re-entrant angle on the lake side at the junction of the rubble mound extension with the crib and concrete breakwater. In anticipation of extraordinary wave stresses being exerted against both structures at this point, unusual care has been taken in the use and placing of extra heavy stones.

Fig. 8 shows a view of the completed rubble mound on the lake front and along the outer portion of the breakwater.

Fig. 9 shows the outer end of the completed rubble mound, its junction and angle with the crib-concrete breakwater, and distant view of the last-named breakwater.

Fig. 10 is a view from the lake front showing the junction of the rubble mound with the concrete-crib breakwater and riprap placed against crib at the re-entrant angle on the lake side.

Fig. 11 shows the salient angle at junction of the rubble mound

Fig. 7. View along lake side of the rubble mound, range marks painted in white upon concrete superstructure of the older breakwater and re-entrant angle formed by junction of the rubble mound extension with the crib and concrete breakwater.

with the concrete-crib breakwater and the point of beginning of the rubble mound.

The inspection and immediate supervision of the work under the fourth and final contract was under the charge of a United States junior engineer, assisted by one or two inspectors as the exigencies of construction demanded. All scows were provided with tonnage gauges, which were read and recorded immediately before and after unloading. Any stone not complying with the 100-pound

minimum requirement was estimated and deducted from the tonnage shown by the gauges. A system of daily, ten-day and monthly reports was adopted which proved satisfactory in field and office. The daily report blanks were in duplicate and bound in a book of convenient pocket size, a duplicate copy for each day accompanied the ten-day report which was forwarded to the office on the 10th. 20th and last day of each month.

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In addition to the reports described a progress sheet, in plan,

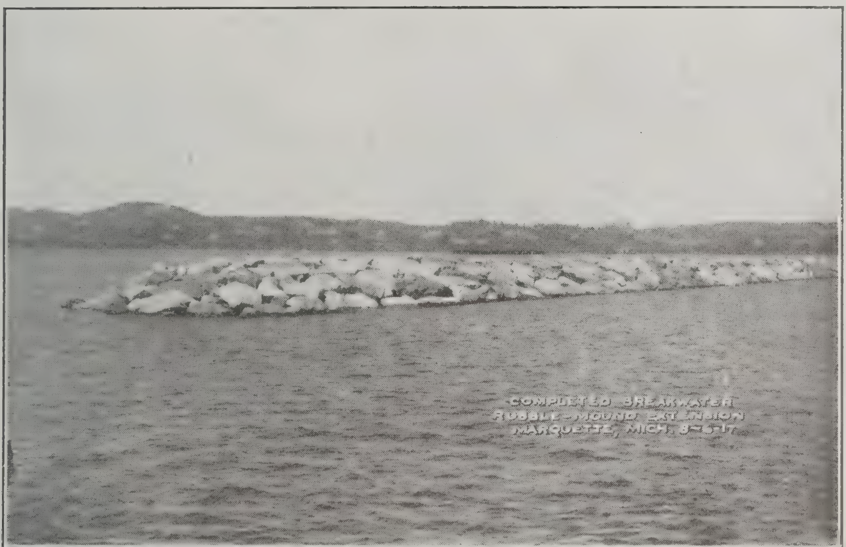


Fig. 8. View along lake side of completed breakwater toward the outer end.

was kept and forwarded with each monthly report. This sheet showed by means of distinctive hatched areas each completed part where the covering stone had been placed, and the month and year in which it was placed; it also showed the stations, depths of water, low water datum, and each course of the covering stone. This sheet is considered of great value during the progress of the work and as a source of ready information and as a record to be preserved after the work has been completed.

The author sees no reason to change his opinion as to the design or basis upon which the original estimate was made, and the same

Fig. 9. View showing outer end of completed rubble mound extension.

Fig. 10. View from lake front, showing the junction of the rubble mound with the crib concrete breakwater.

may be said for the methods of carrying the work through to completion.

The exclusion of quarry run of stone is believed to be economical and the slightly reduced percentage of voids shown in the actual results is believed to be due to the introduction into the work of a relatively small amount of stone under 100 pounds to the piece which the contractor was allowed to waste in the work and for which no payment was made. The specifications for this work are believed to be in the main suitable for this class of work, with the one exception of the provision that "No core stone will be accepted or paid

Fig. 11. View along breakwater from harbor side, showing the completed rubble mound extension for the full length of 1,500 feet.

for that is more than 250 feet in advance of the completed section." It is believed that this question should be left within the discretion of the engineer responsible for the work. Under certain conditions it inflicts a great hardship upon the contractor through the accumulation of core stone at the source of supply, which proves a serious hindrance to the handling and transportation of the large covering stone. Conversely, it reflects against the contracting party in causing vexatious delays and contentions. Under conditions which have prevailed in the author's experience at Marquette Harbor, economy and dispatch would have been increased by the omission from the specifications of the distance limit of core stone in advance of the

completed section. This requirement was purposely omitted by the author from the specifications for rubble mound construction at Superior Entry, Wisconsin, and resulted in giving the contractor an opportunity to make headway at the quarry for the handling of the larger stone for covering, and at the same time protected the breakwater site in no small degree from deepening by scour.

The work of building the embankment intended to serve as a foundation for the proposed cribs with superimposed concrete superstructure was under the direction of Major (now Colonel) Francis R. Shunk, Corps of Engineers (with the exception of an interim from February 1 to March 12, 1912, when it was in charge of First Lieutenant (now Major) John N. Hodges, Corps of Engineers) from March 23, 1911, to August 4, 1912, and from that date to its completion on October 4, 1913, under the direction of Maj. E. D. Peek, Corps of Engineers, with Mr. John H. Darling, Assistant Engineer, and Mr. G. A. Taylor, Junior Engineer, in immediate charge.

The modification of the plan from a crib-and-concrete structure to a rubble mound breakwater authorized August 21, 1914, the preparation of the specifications and the commencement and prosecution of the work continued under the direction Maj. E. D. Peek until October 24, 1916. From that date until April 30, 1917, under the direction of Lieutenant Colonel (now Colonel) E. H. Schulz, Corps of Engineers, and from April 30, 1917, to completion under the direction of Col. D. W. Lockwood, U. S. Army, retired.

The author had immediate charge of the construction of the rubble mound extension to the breakwater from its inception in 1914 to its completion in 1917, and wishes to acknowledge here the able support of the Officers of the Corps of Engineers under whom he worked, as also the very efficient help of his assistants, Mr. S. M. White, Junior Engineer, inspector in charge on the work, and Mr. Chas. Carisch, Junior Engineer, draftsman in the U. S. Engineer Office at Duluth, Minn.

USE OF THE GENERAL RESERVE IN GRAND TACTIC MANEUVERS AS ILLUSTRATED IN THE RUSSO-JAPANESE WAR

By

Col. W. A. Mitchell
Corps of Engineers

The student of history is apt to spend his time on the strategy of campaigns, to the exclusion of the tactics. Our army officers are much more familiar with the strategical errors of the commanders-in-chief than with the tactical errors of the commanders or their subordinates. It is quite customary to write criticisms of Grant for his error in ordering the assault at Cold Harbor; it is unusual to criticize his subordinates who failed to show judgment in carrying out his commands and thus added to the fatalities of that day.

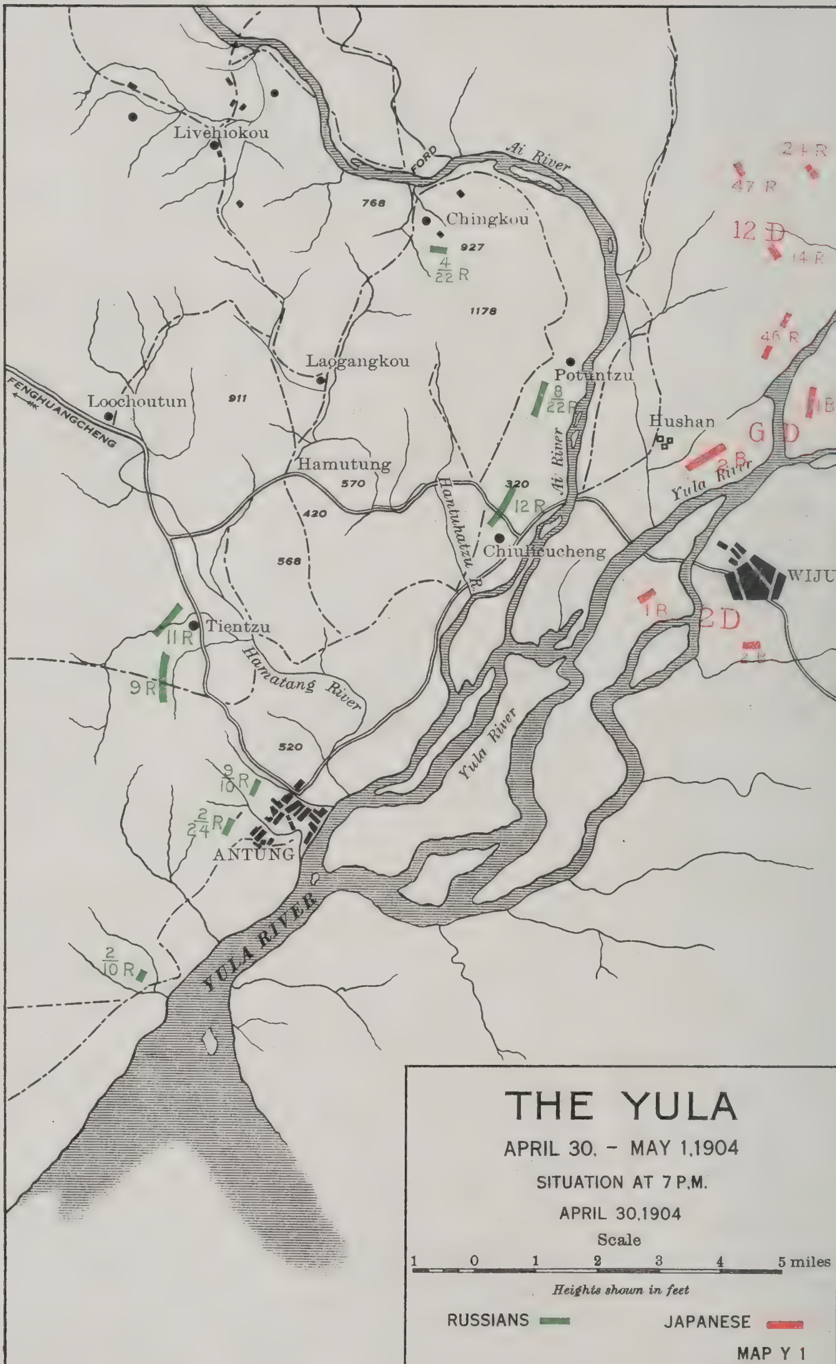
The student of Napoleon's campaigns is invariably impressed with the fact that few of Napoleon's marshals were able strategists, but he fails to notice that they were able tacticians. Often the student wonders why Napoleon ever retained such generals, and entirely forgets that these generals rose through experience in actual conflict, and were the ablest tacticians of their day. Napoleon felt that he could handle the strategy; he felt that his generals could handle the tactics.

It is well for our officers to devote the greater part of their time to the study of tactics. Not one out of one thousand will ever be in such position that he will have to solve great strategical problems, while practically every one will sooner or later have to solve such tactical problems.

Use of Reserves. In this study, only the final reserve is considered; that is, the reserve at the disposition of the commander. This reserve is usually designated as the *General Reserve.*

Briefly, it may be stated that a General Reserve is for actual use in fighting; it is to be used in obtaining the supreme decision; it is a detachment in every sense of the word, and if it is not used by the commander, it might as well be 100 miles away, except for the mental comfort of its presence.

Naturally, the question arises as to just when the reserve should


Livehiokou
FORD
Ai River
768
Chingkou
927
4/22 R
1178
Laogangkou
Potuntzu
8/22 R
Loochoutun
911
FENGHUANGCHENG
Hushan
Hamutung
570
320
12 R
Ai River
Hantuhatzu R.
420
Chiulieucheng
568
Yula River
WIJU
Tientzu
11 R
9 R
Hamatang River
Yula River
520
9/10 R
2/24 R
ANTUNG
YULA RIVER
2/10 R
24 R
47 R
12 D
14 R
46 R
G D
1 B
2 D
THE YULA
APRIL 30. - MAY 1,1904
SITUATION AT 7 P.M.
APRIL 30,1904
Scale
1 0 1 2 3 4 5 miles
Heights shown in feet
RUSSIANS
JAPANESE
MAP Y 1

be used. Napoleon generally kept it for his own use at the supreme moment; but even Napoleon erroneously failed to use it at Borodino, because he did not feel justified in taking the risk.

There are two general methods of handling reserves. Some tacticians claim that a general should study the situation from all possible angles, decide on his line of action, and issue orders before the battle as to the complete operations of his reserve. Other tacticians claim that the general should not issue specific orders for use of his reserve at the beginning, but should save it for the supreme moment, and should then use it to force the supreme decision for victory, or to save the army in retreat. These ideas are somewhat different. The first system is more practicable for offense, but often results in improper use of the reserve; the second system is more suitable for defense, but generally results in no use whatever of the reserve.

The studies presented below are for the purpose of showing the results obtained in actual warfare by use of the different systems.

METHOD OF PRESENTING DISCUSSION.

In this article, brevity is secured at expense of detail by omitting all reference to the operations of artillery, cavalry, etc., where these operations have had no direct and conclusive bearing on the use of the general reserve.

Each battle is considered under the following headings:

Preceding Events: This includes only such of the events preceding the battle as may be needed for obtaining an intelligent idea of the battle itself.

Combatant Troops: This includes all troops available for the use of the highest commanders present.

History of the Battle: This includes a short statement of the operations of the troops during the battle.

Comments: These are often interspersed in the History of the Battle; they include discussion of the possible employment of the General Reserve at different periods of the battle, and remarks as to the probable effect of such employment or reasons for not so doing.

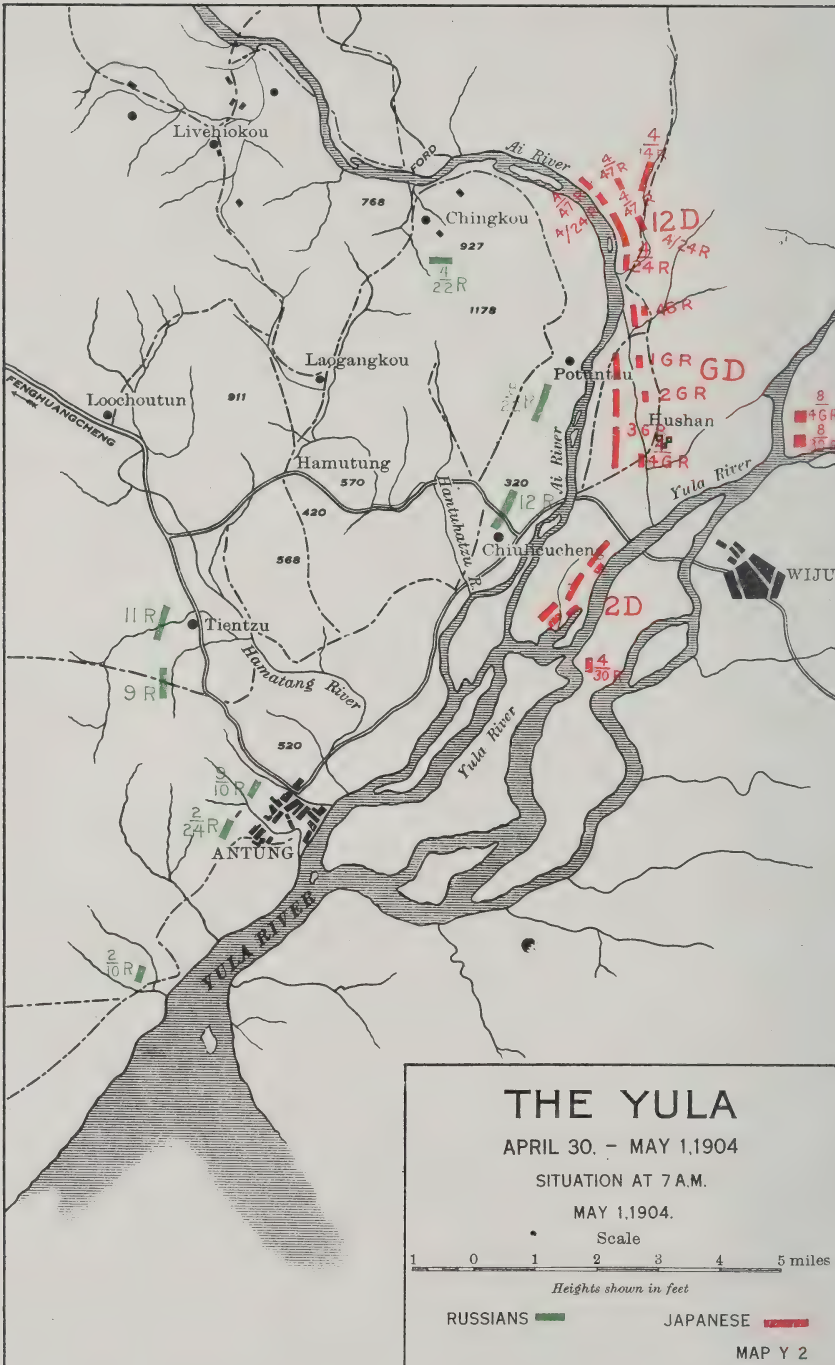
Maps: These show the different positions of the troops at different stages of the battle on the different days, and sometimes at different hours of the same day. The following terms are used on the maps:

Russians (Green). Japanese (Red).

5/6R=five companies of Sixth Regiment;

1R,7R/5B/3D=First and Seventh Regiments of Fifth Brigade of Third Division;

7/6R/IIIC=seven companies of Sixth Regiment of III Corps.


Livehiokou
Ai River
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Chingkou
768
927
1178
12D
GD
Laogangkou
Loochoutun
FENGHUANGCHENG
911
Potuntzu
Hushan
Hamutung
570
420
320
568
Ai River
Yula River
Hantuhatzu R.
Chiulicuchen
WIJU
2D
Tientzu
Hamatang River
520
Yula River
ANTUNG
YULA RIVER
THE YULA
APRIL 30. - MAY 1,1904
SITUATION AT 7 A.M.
MAY 1,1904.
Scale
1 0 1 2 3 4 5 miles
Heights shown in feet
RUSSIANS
JAPANESE
MAP Y 2

REFERENCES.

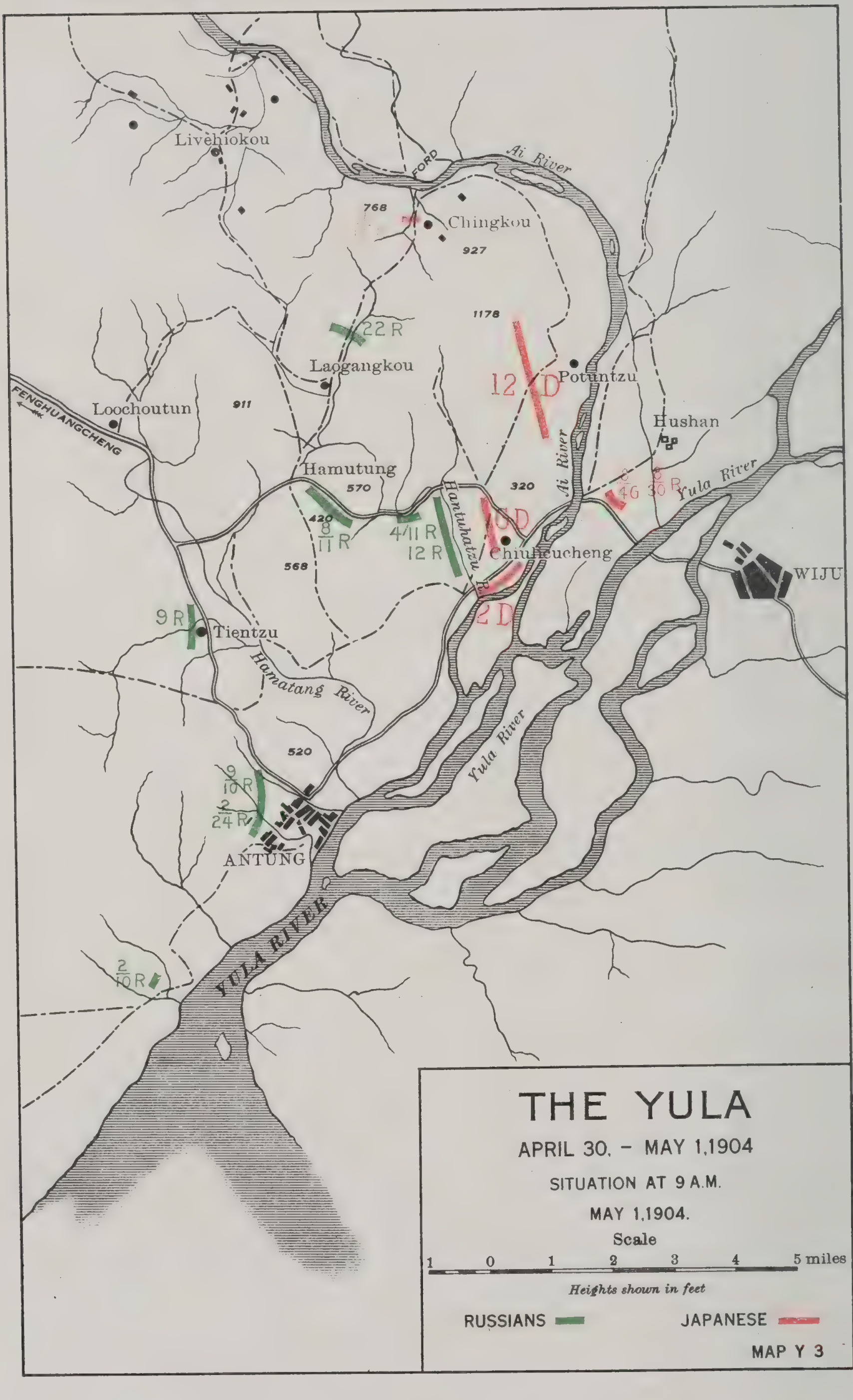
The following books were consulted in obtaining the data for the results herewith. Parenthetical references in the discussion mean that the particular statement is based on the information found on the numbered page of the book designated in the list below by the stated letter. Thus (A301, E27) means that the preceding statement is based on the information found on page 301, of Guerre Russo-Japonaise, Russian, Vol. I, and on page 27 of Official History of the Russo-Japanese War, English (Naval and Military) Vol. I.

A Guerre Russo-Japonaise, Russian, Vol. I.
B Guerre Russo-Japonaise, Russian, Vol. II.
C Guerre Russo-Japonaise, Russian, Vol. III.
D Guerre Russo-Japonaise, Russian, Vol. IV.
E Official History of the Russo-Japanese War, English (Naval and Military), Vol. I.
F Official History of the Russo-Japanese War, English (Naval and Military), Vol. II.
G Official Account of the Russo-Japanese War, German, Yalu.
H Official Account of the Russo-Japanese War, German, Wafangou.
I Official Account of the Russo-Japanese War, German, Liao Yan.
J Epitome of Russo-Japanese War (U. S.)
K Glassford: Sketch of Manchurian Battlefields.
L Kuropatkin: Russian Army and Japanese War.
M Asiaticus: Reconnaissance in the Russo-Japanese War.
N Official History of the Russo-Japanese War, English, Part I.
O Official History of the Russo-Japanese War, English, Part II.
P Official History of the Russo-Japanese War, English, Part III.
Q Official History of the Russo-Japanese War, English, Part IV.

For research, the official histories are especially satisfactory because they generally quote the original orders, telegrams, etc., referring to the operations of the troops.

GENERAL STRATEGY OF RUSSIANS AND JAPANESE.

Gen. Kuropatkin had studied the resources in men and material of the two countries before the commencement of the war. He understood that the Russians could not successfully oppose the Japanese at once; and he planned to fight delaying actions at every opportunity until he should have received enough troops to render successful a tactical offensive. He could not adhere consistently to this general plan, because of the wishes of the Czar, and of Viceroy Alexieff. So we find that at times he directed his troops to attack the Japanese; he did not always order them to fight delaying actions.



THE YULA
APRIL 30. - MAY 1,1904
SITUATION AT 9 A.M.
MAY 1,1904.
Scale
1 0 1 2 3 4 5 miles
Heights shown in feet
RUSSIANS
JAPANESE
MAP Y 3
Livehiokou
Ai River
FORD
768
Chingkou
927
1178
22 R
Laogangkou
12 D
Potuntzu
Loochoutun
911
FENGHUANGCHENG
Hushan
Hamutung
570
320
Ai River
Yula River
420
8/11 R
4/11 R
12 R
Hantuhatzu R.
Chiulieucheng
WIJU
568
2 D
9 R
Tientzu
Hamatang River
520
Yula River
9/10 R
2/24 R
ANTUNG
YULA RIVER
2/10 R

The Japanese also understood that their best opportunity lay in an active offensive with view to decisive victory before the arrival of too great numbers of Russian troops from Europe.

THE YALU.

Preceding Events. The first Japanese Army, under Gen. Kuroki, landed at Chemulpo and further north on the west coast of Korea on February 8th, and later it marched north, and in the latter part of April found the Russian Army, under Gen. Sassulitch, along the Yalu.

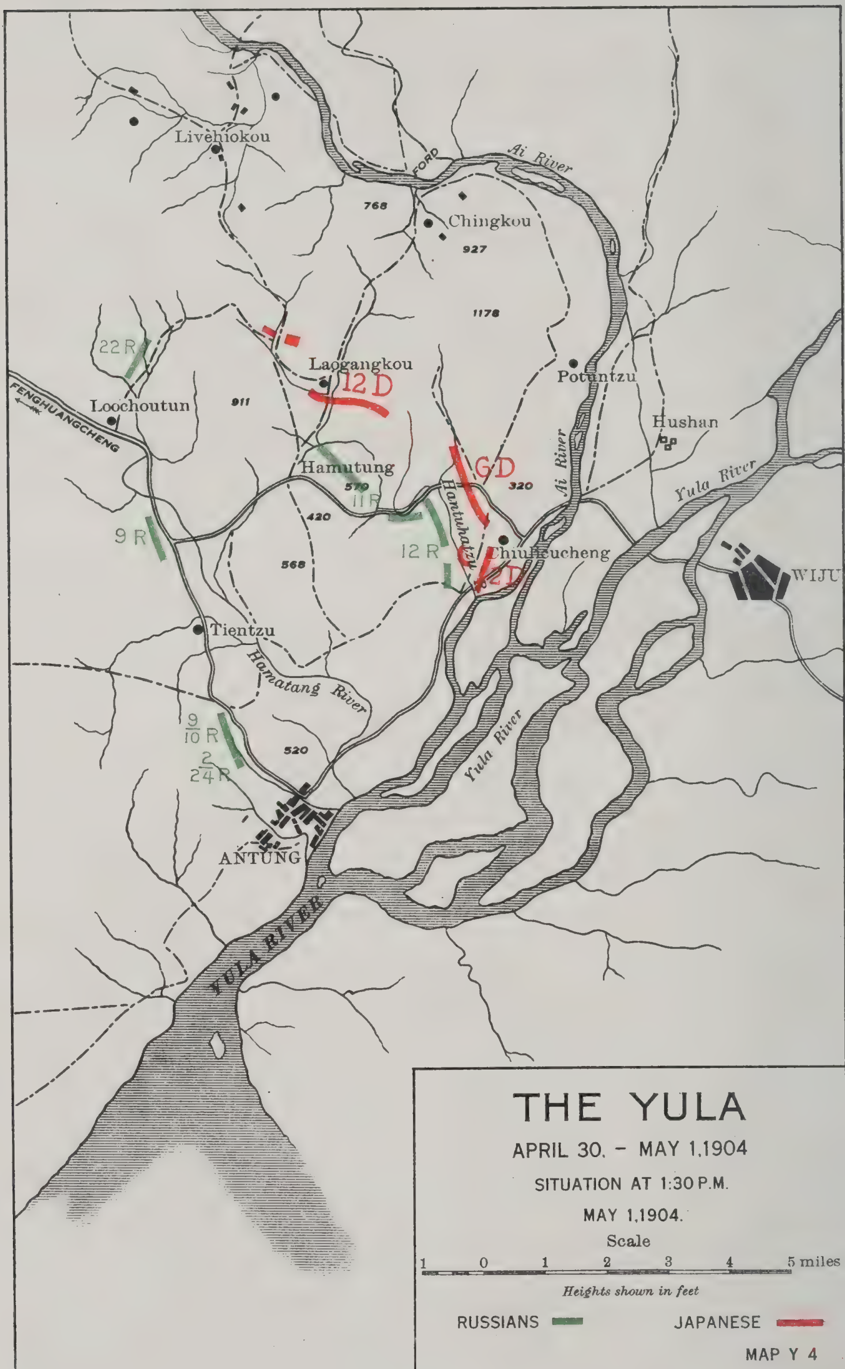
Combatant Troops. On April 30th and May 1st the forces were (N89):

Russians.	Bns.	*Japanese.*	Bns.
3rd East Sib. Rifle Division:		Guard Division:	
9th E. S. R. Regt.	3	1st Guard Regt.	3
10th E. S. R. Regt.	3	2nd Guard Regt.	3
11th E. S. R. Regt.	3	3rd Guard Regt.	3
12th E. S. R. Regt.	3	4th Guard Regt.	3
6th East Sib. Rifle Division:		2nd Division:	
21st E. S. R. Regt.	3	4th Regt.	3
22nd E. S. R. Regt.	3	29th Regt.	3
23rd E. S. R. Regt.	3	16th Regt.	3
24th E. S. R. Regt.	3	30th Regt.	3
		12th Division:	
		14th Regt.	3
		47th Regt.	3
		24th Regt.	3
		46th Regt.	3
	24		36
Bayonets	17,000	Bayonets	36,000

History of the Battle; Comments (Map Y1):

On the morning of April 30th, some of the Japanese artillery opened on the Russians near Chiuliencheng. The Russian artillery soon stopped firing. By noon, a small Russian detachment at Hushan had been forced back across the Ai River, and practically no Russians were left east of the Ai River or south of the Yalu. The Japanese spent the rest of the day in preparing to cross the east fork and branches, in crossing, and moving into position. The positions about 7:00 P. M., April 30th, are shown on Map Y1; the positions about daybreak, May 1st, are shown on Map Y2.

The Russian commander did not intend to fight a decisive battle (N55, G171); but he was ordered to make an obstinate resistance.


Livehiokou
Ai River
FORD
768
Chingkou
927
1178
22 R
Laogangkou
12 D
Potuntzu
FENGHUANGCHENG
Loochoutun
911
Hushan
Hamutung
GD
579
11 R
320
Ai River
Yula River
9 R
420
Hantuhotzu
Chiuliencheng
12 R
2D
568
WIJU
Tientzu
Hamatang River
9/10 R
2/24 R
520
Yula River
ANTUNG
YULA RIVER
THE YULA
APRIL 30. - MAY 1,1904
SITUATION AT 1:30 P.M.
MAY 1,1904.
Scale
1 0 1 2 3 4 5 miles
Heights shown in feet
RUSSIANS
JAPANESE
MAP Y 4

On April 30th, he had 17,000 bayonets available; but some of these, viz: 11/12 of 21st Regiment, all of 23rd Regiment, 5/12 of 24th Regiment, 1/12 of 10th Regiment, total about 5,000 men, were on the immediate line of communications or a little farther back (N93). All of the Japanese army was available. (See Map Y1.)

On May 1st, the situation (Map Y2) was as follows:

	Russians.	*Japanese.*
At Points of Contact	4,500	32,000
Not at Points of Contact:		
Detachment at Antung and beyond	2,500	
General Reserve	4,500	4,000
Not close enough for Actual Contact	5,000	
	16,500	36,000

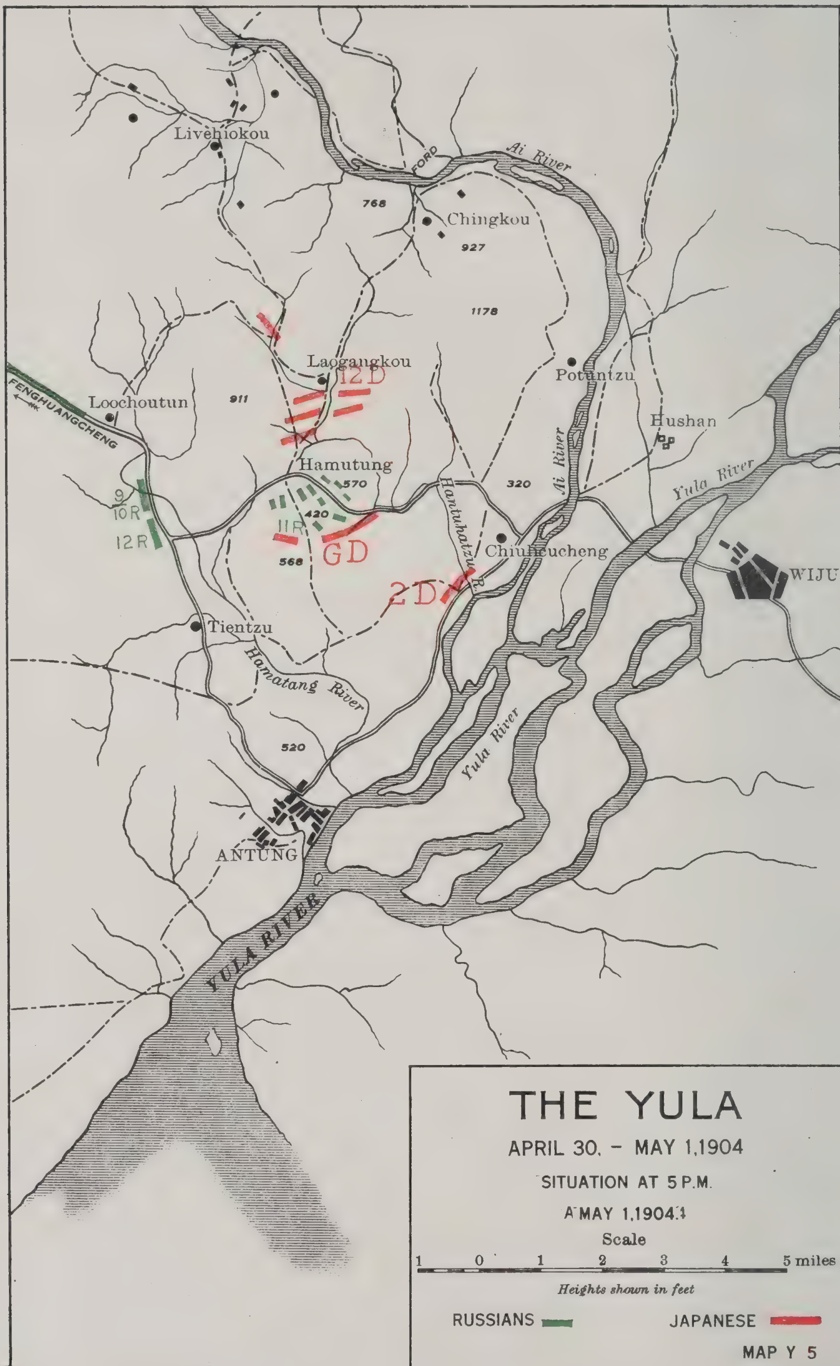
It is thus seen that the Russian commander, with orders to fight an obstinate delaying action at a difficult river crossing, had so arranged his troops that at points of contact he opposed 4,500 Russians to 32,000 Japanese, or about 1 to 7.

At daybreak, May 1st, the Japanese artillery opened fire; the Russian artillery replied for a short time, but stopped at about 6:30 A. M. The Japanese infantry moved forward at 7:30 A. M., forded the Ai River, and attacked. The Russians soon gave way at Potetientzu. The Japanese advanced into the gap, threatened the Russians at Chingkou, and prepared to sweep south against the left of the Russians along the Chiuliencheng position. The situation at about 8:45 A. M. is shown on Map Y3.

By 9:00 A. M., it had become evident to the Russian Commander that he could not stop the Japanese at all with the troops actually fighting. However, he had not taken any decisive step. He had simply ordered the Antung detachment to move to the position of the General Reserve, and had ordered the 11th Regiment to support the troops on the fighting front. About this time, 9:00 A. M., Gen. Kuroki issued his order for the pursuit, and threw forward his whole reserve.

The situation was as follows:

	Russians.	*Japanese.*
At Points of Contact and en route	6,750	36,000
Not near Points of Contact:		
Antung Detachment ordered to Positions of General Reserve	2,500	
General Reserve	2,250	
Not close enough for Actual Contact	5,000	
	16,500	36,000


Livehiokou
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Laogangkou
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Potuntzu
FENGHUANGCHENG
Loochoutun
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Hushan
Hamutung
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Ai River
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10 R
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11 R
12 R
GD
568
Hantuhatzu R.
Chiuliencheng
Yula River
WIJU
2 D
Tientzu
Hamatang River
Yula River
520
ANTUNG
YULA RIVER
THE YULA
APRIL 30. - MAY 1,1904
SITUATION AT 5 P.M.
MAY 1,1904
Scale
1 0 1 2 3 4 5 miles
Heights shown in feet
RUSSIANS
JAPANESE
MAP Y 5

It is thus seen that the Russian commander now expected to fight with some 6,750 bayonets against some 36,000 Japanese, 1 to 5½, and kept out about 10,000 bayonets while the Japanese kept out none.

The Chiuliencheng troops fell back behind the Hantuhotzu River, being reinforced by 2 battalions of 11th Regiment who extended the line to the hills north of Hamatang; the troops at Potetientzu and Chingkou fell back to a position north of Laofangkou.

The Russian commander decided to retreat; and ordered the line to hold behind the Hantuhotzu River and near Laofangkou, so that the Antung troops could get by on the road to Fenghuangcheng, but he sent no more reinforcements to this line. However, the Russians held, partly by desperate fighting and partly because of the fact that the Japanese infantry had to delay its advance against the Hantuhotzu line until the artillery could be brought up to their support.

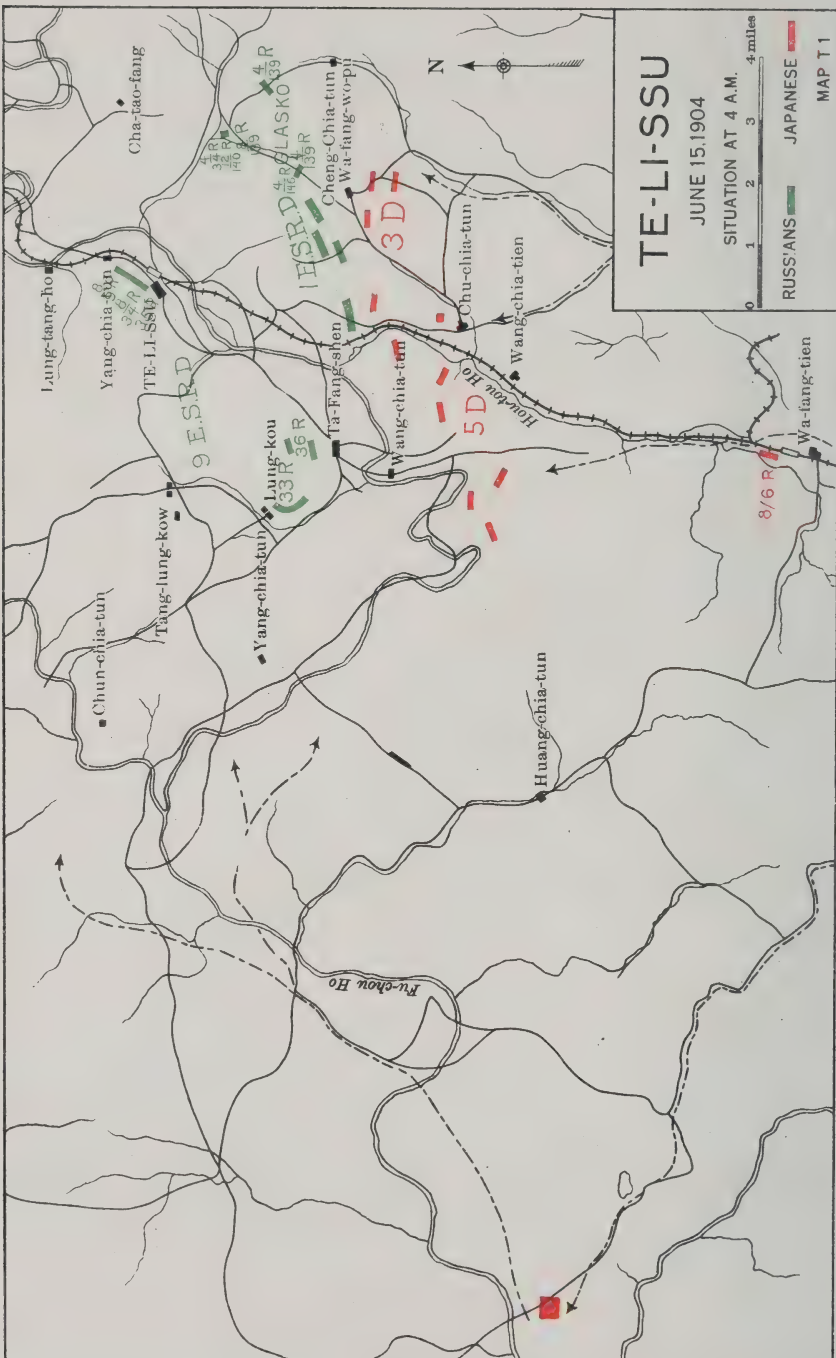
The effectiveness of this resistance does not seem to have suggested any employment of the General Reserve. The Russian commander left the fighting troops to their own devices.

About 1:30 P. M., the Japanese began to break through the new Russian line (see Map Y4). The Russians north of Laofangkou retired westward through Laochoutun. The remainder of the line retired through Hamatang, except some portions of the 11th Regiment, which held their positions southeast of Hamatang, and were captured about 5:00 P. M. (See Map Y5.)

In conclusion, it is seen that 5,000 Russians were detached so far from the field that they could not be in the battle; that 4,750 were available as General Reserve, but did not fire a shot; that 6,750 did all of the fighting. On the Japanese side, every man of their 36,000 was used at some stage of the battle.

It seems probable that, if the Russian commander had used all of his 16,000 men, he might have been successful in this particular situation, for odds of 2 to 1 are not sufficient to capture a well prepared position with a river as obstacle in its front.

It also seems probable that, if the Russian commander had reinforced the fighting troops along the line of the Hantuhotzu, he could have successfully resisted until night and could have withdrawn without serious loss.


TE-LI-SSU
JUNE 15,1904
SITUATION AT 4 A.M.
0 1 2 3 4 miles
RUSSIANS
JAPANESE
MAP T 1
N
Cha-tao-fang
Cheng-Chia-tun
Wa-fang-wo-pu
Lung-tang-ho
Yang-chia-tun
TE-LI-SSU
Ta-Fang-shen
Chu-chia-tun
Wang-chia-tien
Wang-chia-tun
Hou-tou Ho
Lung-kou
Tang-lung-kow
Yang-chia-tun
Chun-chia-tun
Huang-chia-tun
Wa-fang-tien
Fu-chou Ho
1 E.S.R.D.
9 E.S.R.D
GLASKO
3 D
5 D
33 R
36 R
8/6 R

NAN-SHAN

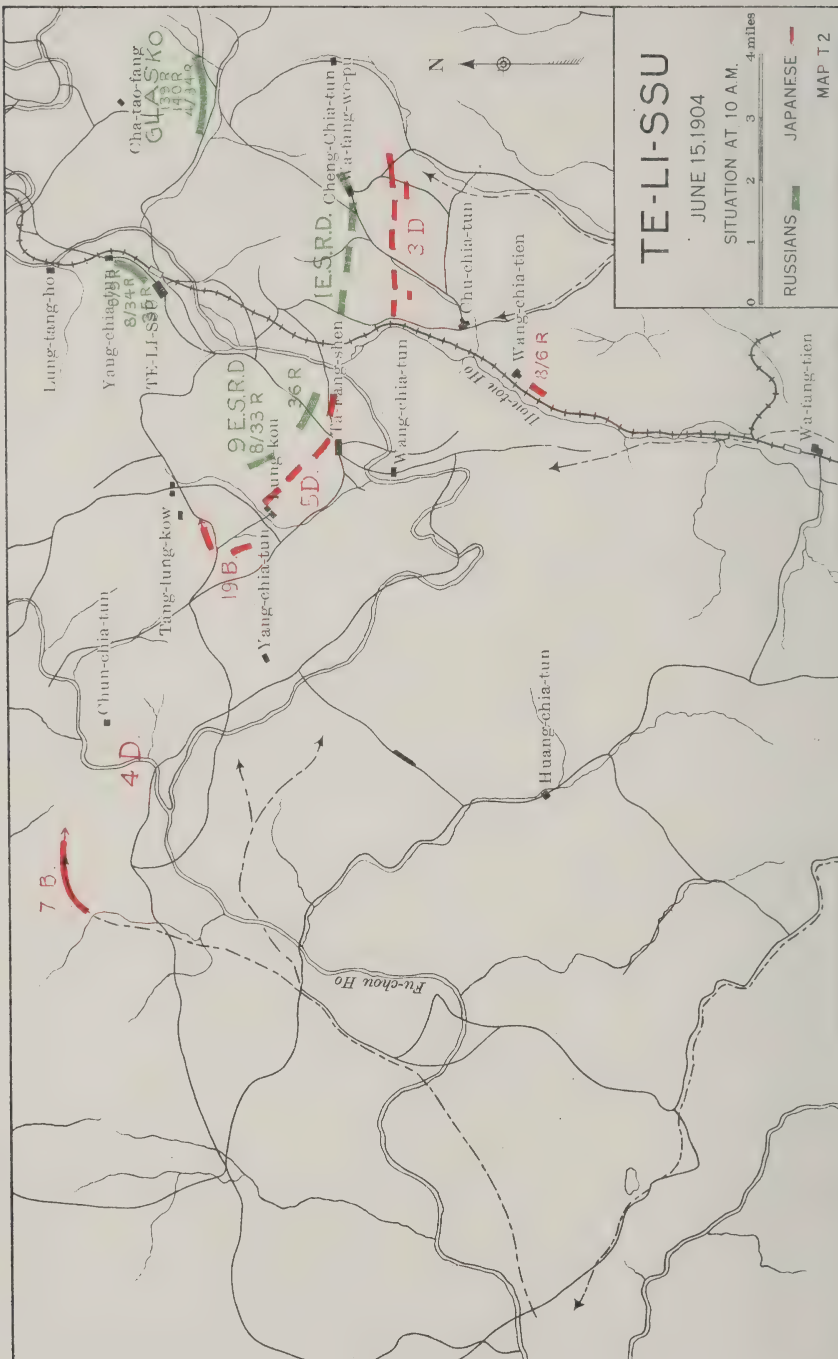
Preceding Events. The Japanese Second Army, under Gen. Oku, landed near Pitsewo on May 5th, with object of cutting the railroad from Mukden to Port Arthur and isolating Port Arthur. After some skirmishing en route, the army reached Nan-Shan Hill on May 25th. This position was naturally strong, and the Russians had increased its defensive strength by elaborate fortifications completed about April 1st.

Combatant Troops. The forces at the disposal of the commanders were as follows:

Russians.	Bns.	*Japanese.*	Bns.
4th East Sib. Rifle Division:		1st Division:	
13th E. S. R. Regt.	3	1st Regt.	3
14th E. S. R. Regt.	3	15th Regt.	3
15th E. S. R. Regt.	3	2nd Regt.	3
16th E. S. R. Regt.	3	3rd Regt.	3
2nd East Sib. Rifle Division:		3rd Division:	
5th E. S. R. Regt.	3	6th Regt.	3
		33rd Regt.	3
		18th Regt.	3
		4th Division:	
		8th Regt.	3
		37th Regt.	2
		9th Regt.	3
		38th Regt.	2
	15		31
Bayonets	15,000	Bayonets	30,000

History of the Battle. About 5:30 A. M., the Japanese artillery commenced the battle. At that time, the troops were disposed as follows:

	Russians. Bns.	*Japanese.* Bns.
Actually in contact or Local Reserve	3	28
General Reserve	½	3
	3½	31


TE-LI-SSU
JUNE 15,1904
SITUATION AT 10 A.M.
0 1 2 3 4 miles
RUSSIANS
JAPANESE
MAP T 2
N
GLASKO
Cha-tao-fang
Cheng-Chia-tun
Wa-fang-wo-pu
I E.S.R.D.
3 D
Chu-chia-tun
Wang-chia-tien
8/6 R
Lung-tang-ho
Yang-chia-tun
TE-LI-SSU
9 E.S.R.D
8/33 R
3/6 R
Ta-fang-shen
Wang-chia-tun
Hou-tou Ho
Wa-fang-tien
5 D.
Lung-kou
19 B.
Yang-chia-tun
Tang-lung-kow
Chun-chia-tun
4 D.
7 B.
Huang-chia-tun
Fu-chou Ho

Close enough for General Reserve	2½	Near Maoyitzu (2 miles from Nan Shan).
	3	Near Lower Nanknanling (4 miles from Nan Shan).
	3	Near Upper Nanknanling (4 miles from Nan Shan).
	3	At Sanshilipu (8 miles from Nan Shan).
	11½	

It is thus seen that at the commencement of the battle, the Russians opposed 3,500 bayonets to the 30,000 bayonets of the Japanese.

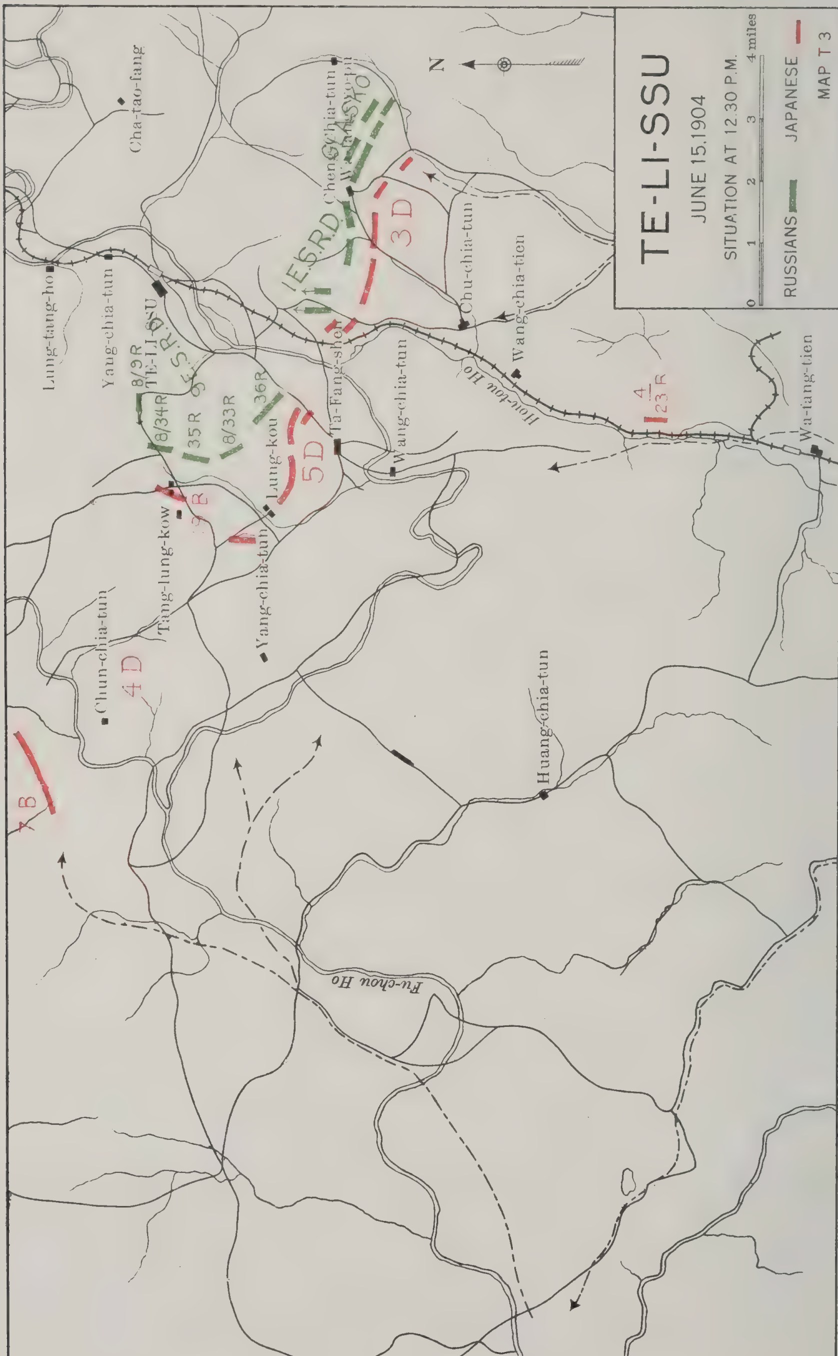
During the battle, the Russian commander in the field repeatedly called for reinforcements. He received only 500 men, yet was able to maintain his position until 7:00 P. M. At this time, *i. e.*, the moment of victory for the Japanese, the Russians had in actual contact 4,000 bayonets against 29,750 of the Japanese; but the Russians had not used, and did not use, 11,000 bayonets which were close enough to be available, as compared with 250 Japanese bayonets similarly available.

Comments. The Japanese lost 4,500 men; the Russians, about 1,000. It is not known why the Russian commander used only 4,000 out of 15,000 bayonets available. As these 4,000 held the position for 12 hours and inflicted a loss of 4,500 on the Japanese, it seems probable that the whole Russian force of 15,000 bayonets could not have been defeated by the 30,000 Japanese.

TELISSU.

Preceding Events. After the victory at Nan-Shan Hill, the Japanese landed more troops. The Third Army, under Gen. Nogi, was formed at Dalny to capture Port Arthur. The Fourth Army, under Gen. Nodzu, was formed at Takushan, to connect the Second and First Armies. The Second Army, under Gen. Oku, now composed of the 3rd, 4th and 5th divisions, moved north along the railroad.

The Russian Commander-in-chief, Gen. Kuropatkin, had been ordered by the Czar to hold the First Japanese Army, and drive the Second Japanese Army into the sea and relieve Port Arthur. His total force available for an operation against the Second Japanese Army consisted of 7 infantry divisions; but he so disposed his troops that at the deciding battle, Telissu, the Russian commander in the field, Gen. Stakelberg, had available a force somewhat less than 3 divisions (O30-31, O134-136).


TE-LI-SSU
JUNE 15.1904
SITUATION AT 12.30 P.M.
0 1 2 3 4 miles
RUSSIANS
JAPANESE
MAP T 3
N
Cha-tao-fang
Lung-tang-ho
Yang-chia-tun
TE-LI-SSU
Chu-chia-tun
Wang-chia-tien
Hou-tou Ho
Ta-Fang-shen
Wang-chia-tun
Lung-kou
Yang-chia-tun
Tang-lung-kow
Chun-chia-tun
Huang-chia-tun
Wa-fang-tien
Fu-chou Ho
3 D
5 D
4 D
8/9R
8/34R
35 R
8/33R
36R

Combatant Troops. The forces at the disposal of the commanders for this battle were as follows:

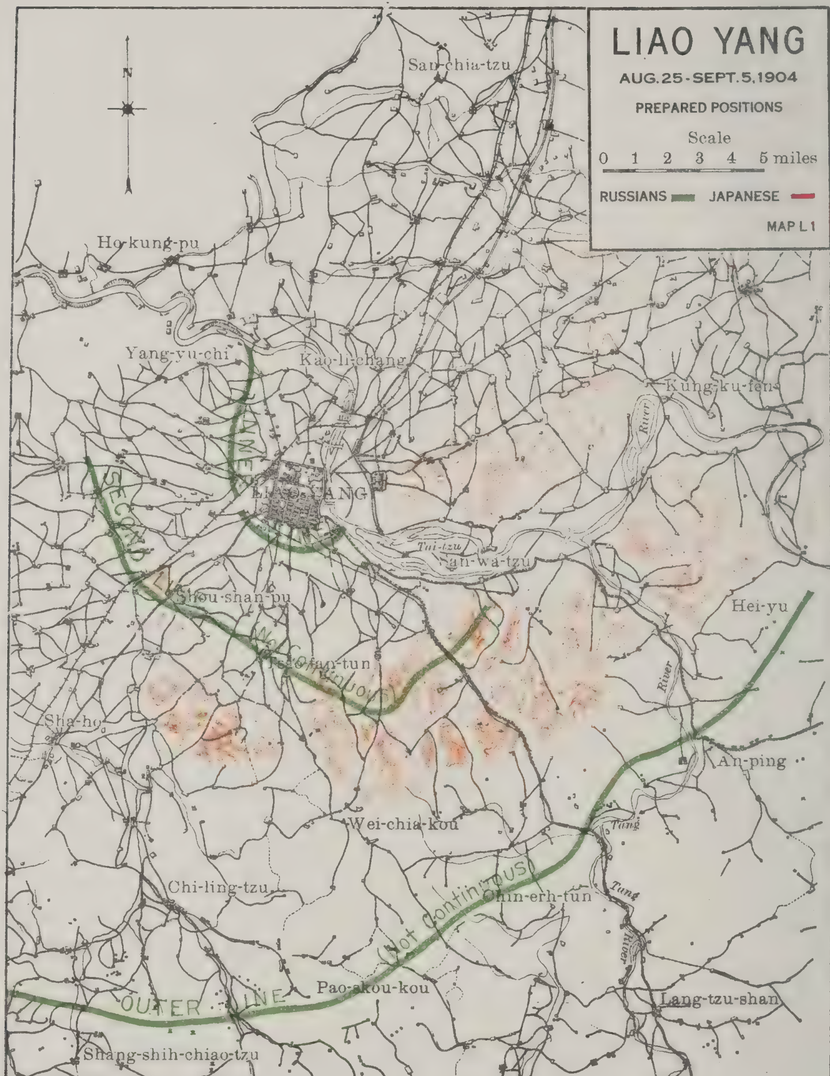
Russian.	Bns.	*Japanese.*	Bns.
1st East Sib. Division:		3rd Division:	
1st E. S. R. Regt.	3	6th Regt.	3
2nd E. S. R. Regt.	3	33rd Regt.	3
3rd E. S. R. Regt.	3	18th Regt.	3
4th E. S. R. Regt.	3	34th Regt.	3
9th East Sib. Rifle Division:		4th Division:	
33rd E. S. R. Regt.	2	8th Regt.	3
34th E. S. R. Regt.	3	37th Regt.	3
35th E. S. R. Regt.	3	9th Regt.	3
36th E. S. R. Regt.	3	38th Regt.	3
3rd Sib. Inf. Division:		5th Division:	
9th Regt.	4	11th Regt.	3
35th Inf. Division:		41st Regt.	3
139th Regt.	4	21st Regt.	3
140th Regt.	4	42nd Regt.	3
		6th Division:	
		23rd Regt.	1
	35		37
Bayonets	25,000	Bayonets	30,000

The 6th Japanese division marched to the battlefield, but only one battalion arrived in time to be available. Two of the four battalions of the 9th Russian regiment arrived by rail during the battle.

History of the Battle. Desultory fighting took place on June 14th. The Russians repulsed an attack against their eastern flank. The Russian commander, Gen. Stakelberg, then changed from a defensive to an offensive attitude, decided to attack next morning, and ordered Gen. Glasko, with all of his reserves, to his eastern flank for an attack next morning. This use of reserves was an unusual proceeding for a Russian commander; but he relied for general reserve on more troops coming by rail, which arrived during the night.

The situation at 4:00 A. M., June 15, was as follows (Map T1):

	Russians. Bns.	*Japanese.* Bns.
Ready for Actual Contact or in Local Reserve	26 (18,200)	22 (17,600)
General Reserve	7	2
Coming up—can arrive in time for battle:		
9th Regiment	2	--
4th Division	--	12
23rd Regiment	--	1
	35	37


LIAO YANG
AUG. 25 - SEPT. 5, 1904
PREPARED POSITIONS
Scale
0 1 2 3 4 5 miles
RUSSIANS
JAPANESE
MAP L 1
N
San-chia-tzu
Ho-kung-pu
Yang-yu-chi
Kao-li-chang
Kung-ku-fen
River
LIAO YANG
Tai-tzu
San-wa-tzu
SECOND
LINE
Shou-shan-pu
(Not Continuous)
Tsao-fan-tun
Hei-yu
River
Sha-ho
An-ping
Wei-chia-kou
Tang
Chi-ling-tzu
(Not Continuous)
Chin-erh-tun
Tang
River
OUTER LINE
Pao-akou-kou
Lang-tzu-shan
Shang-shih-chiao-tzu

It is thus seen that the troops in actual contact were almost equal in numbers.

However, the Russian attack on the east did not proceed properly. The 1st East Siberian Rifle Division attacked, but was not supported by the 9 battalions of Gen. Glasko. Meanwhile the 4th Japanese Division had sent the 19th Brigade to extend the left of the 5th Japanese Division, which had slowly forced back the Russians in its front.

The situation at 10:00 A. M., June 15, was as follows (Map T2):

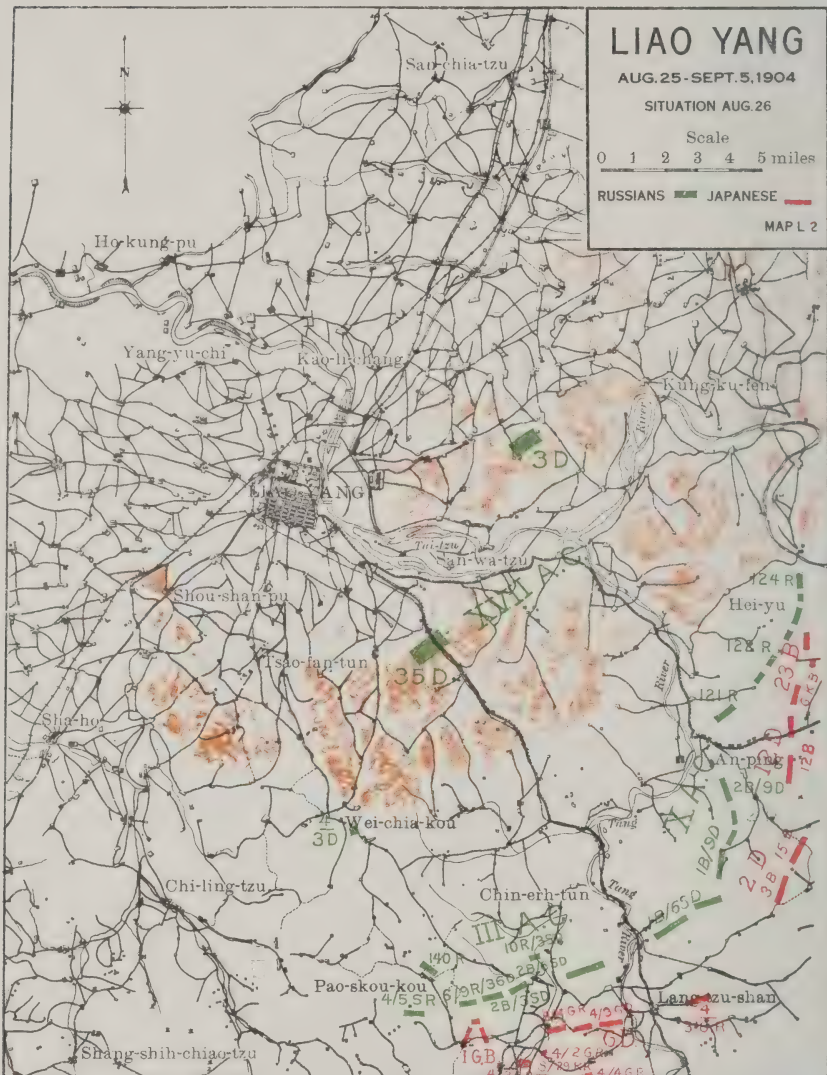
	Russians.	*Japanese.*
	Bns.	Bns.
Actually in Contact or Local Reserve	26	28
	(18,200)	(22,400)
General Reserve	7	2
Coming up—can arrive in time for battle:		
9th Regiment	2	--
7th Brigade	--	6
23rd Regiment	--	1
	35	37

It is seen that the Japanese, at 10:00 A. M., had more troops in actual contact than the Russians.

The Russian commander reinforced his right with all of his reserve, and ordered Gen. Glasko, on his eastern wing, to attack. The Japanese commander sent all his reserve to the 3rd Division, which was being pressed. Before these movements could become effective, the western regiment of the 1st East Siberian Rifle Division had been driven back, by flanking, from the 5th Japanese Division. This disaster, and the report of the approach of the 7th Japanese Brigade (strength unknown to the Russians) caused the Russian commander to order a retirement.

The situation at 12:30 P. M., June 15, was as follows (Map T3):

	Russians.	*Japanese.*
	Bns.	Bns.
Actually in Contact or Local Reserve	33	30
	(23,100)	(24,000)
General Reserve	--	--
Coming up—can arrive in time for battle:		
9th Regiment	2	--
7th Brigade	--	6
23rd Regiment	--	1
	35	37


LIAO YANG
AUG. 25 - SEPT. 5, 1904
SITUATION AUG. 26
Scale
0 1 2 3 4 5 miles
RUSSIANS
JAPANESE
MAP L 2
N
San-chia-tzu
Ho-kung-pu
Yang-yu-chi
Kao-li-chiang
Kung-ku-fen
LIAO YANG
San-wa-tzu
Shou-shan-pu
Hei-yu
Tsao-fan-tun
Sha-ho
An-ping
Wei-chia-kou
Chi-ling-tzu
Chin-erh-tun
Pao-skou-kou
Lang-tzu-shan
Shang-shih-chiao-tzu
3D
35D
XVII A.C.
III A.C.
X A.C.
124 R
128 R
121 R
23 B
12 B
2B/9D
1B/9D
1B/6SD
10R/35D
140 R
6/9R/36D
2B/6SD
4/5 S R
2B/35D
1 G B
4/2 G B
4/4 G B
GD
2 D

It is seen that, at 12:30 P. M., the forces actually in contact were about equal. When the Russians commenced the retirement, the situation on the battlefield itself slightly favored the Japanese, as they had not been actually driven back on their right, and they had actually driven back the Russian right.

The Russians lost heavily in their retirement, principally because there was only one good road available.

Comments. This battle differs from other battles in this war in that the Russian commander made effective use of his reserve. Had he not so used his reserve, it is possible that the whole of his left wing would have been destroyed. Similarly, the Japanese commander saved the situation for his side by promptly sending all of his general reserve to reinforce his hard-pressed right wing.

Man for man, the opposing forces seem to have been well matched. The Russian right had been driven back; and the Japanese right might have been driven back in a short time if the Russian commander had not decided to retire, for reasons previously stated.

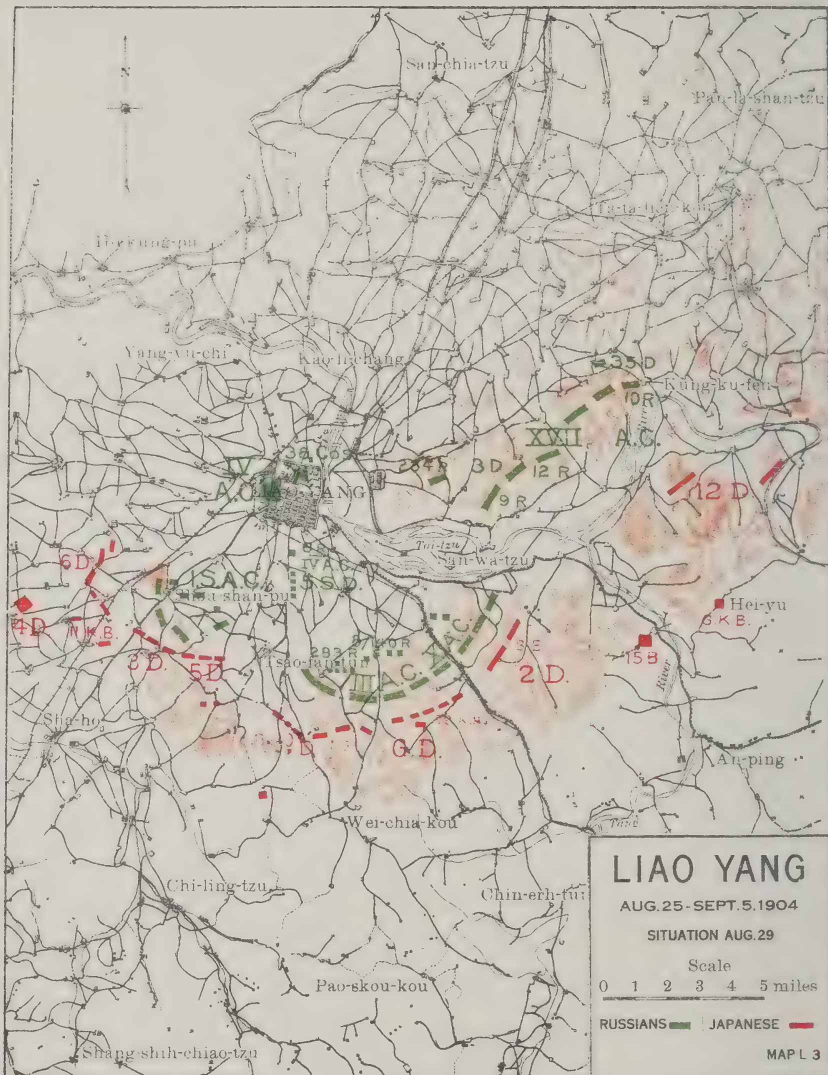
This battle shows that a general reserve should be used. It also shows that a defeated army will not at all be destroyed simply because it has no fresh general reserve to cover its retreat.

LIAO YANG.

Preceding Events. The First Japanese Army, under Gen. Kuroki, did not rapidly advance on Liao Yang, but waited for the completion of operations of the Japanese Second, Third and Fourth Armies, which were operating to the south of Liao Yang. The Third Army invested Port Arthur, and the Second and Fourth Armies slowly forced their way toward Liao Yang. By August 24, the First, Second and Fourth Japanese Armies were close enough to Liao Yang to menace the safety of that place.

Meanwhile, the Russian forces, in and around Liao Yang, had been considerably increased until Gen. Kuropatkin finally resolved to accept a decisive battle. (I8, 225; Q12.)

It is estimated that the Russian battalions averaged 650 bayonets, while the Japanese battalions averaged 1,000. In the tables, showing the estimates of strength of battalions each day, the relative strength only is given, as no deduction is made on either side. for losses recently sustained.


LIAO YANG
AUG. 25 - SEPT. 5. 1904
SITUATION AUG. 29
Scale
0 1 2 3 4 5 miles
RUSSIANS
JAPANESE
MAP L 3
San-chia-tzu
Pan-la-shan-tzu
Yang-yu-chi
Kao-li-chang
Kung-ku-fen
35 D
10 R
XVII A.C.
3 D
12 R
9 R
12 D.
IV A.C.
I S.A.C.
III A.C.
2 D.
6 D.
4 D.
N.K.B.
3 D.
5 D.
G.D.
Hei-yu
G.K.B.
15 B
San-wa-tzu
Tsao-fan-tun
Sha-ho
An-ping
Wei-chia-kou
Chi-ling-tzu
Chin-erh-tun
Pao-skou-kou
Shang-shih-chiao-tzu
N

Combatant Troops (Q11, J57):

Western Group.

Russians.	Bns.	*Japanese.*	Bns.
Zarubaiev:		Second Army—Oku:	
1st Sib. Corps	21	3rd Division	12
5th East Sib. Rifle Div.	12	4th Division	11
4th Sib. Corps	24	6th Division	12
		11th Kobi Brigade	6
		Fourth Army—Nodzu:	
		5th Division	12
		10th Division	12
		10th Kobi Brigade	6
	57		71

Eastern Group.

	Bns.		Bns.
Bilderling:		First Army—Kuroki:	
3rd Siberian Corps	24	Guard Division	12
X Corps	32	2nd Division	12
XVII Corps	11	12th Division	12
		Kobi Brigade	6
	67		42

Elsewhere.

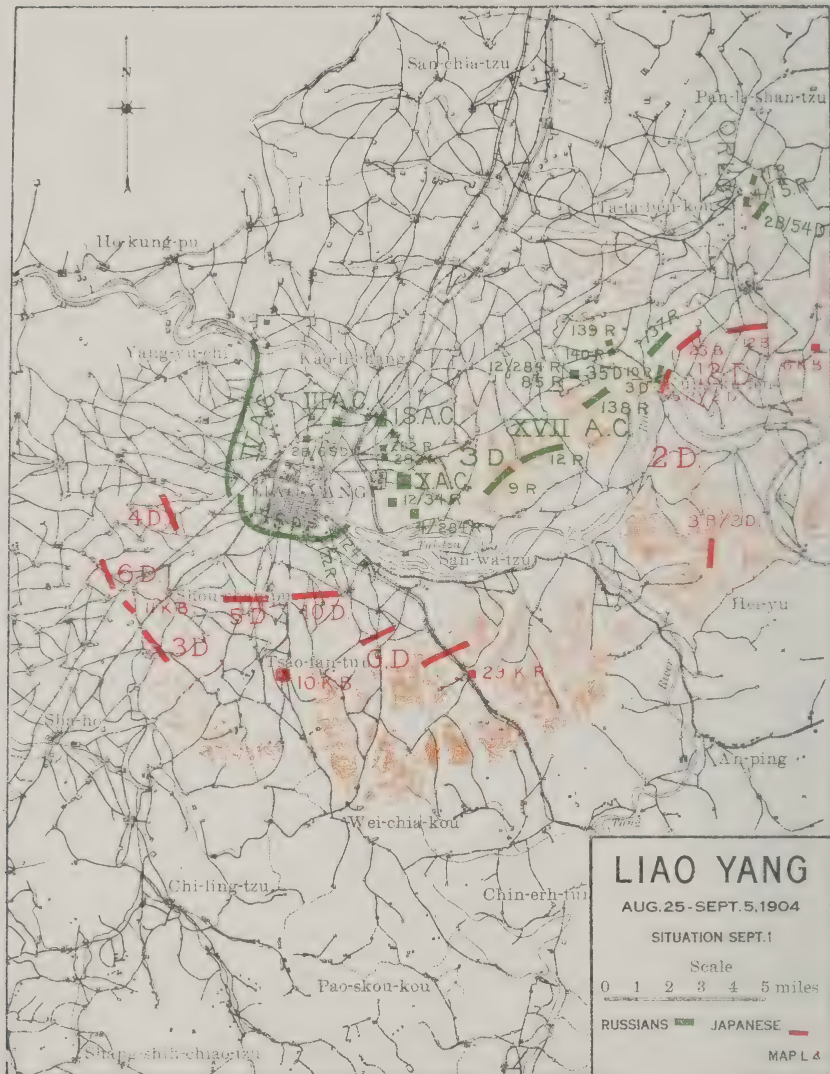
	Bns.		Bns.
Liao Yang	32		
Mukden	27		
Penhsibu	5		
Colonel Madritor	2		
Tawan	3		
	69		
Grand total	193	Grand total	113
Bayonets	125,000	Bayonets	110,000

(Q12, I12, H138).

History of the Battle, Comments. The Russians had intrenched three lines of defense, the inner one with especially great care. (See map L1.)

Gen. Kuropatkin at first decided to fight a delaying action in his outer line, and his main battle in his second line; but on August 24, he decided to offer strenuous resistance on his outer line and take offensive, if favorable opportunity offered. (I15.)

August 25. The Japanese used this day in developing the Russian advanced positions, and the guard division captured a portion of the Russian advanced positions. This was not a very important


LIAO YANG
AUG. 25 - SEPT. 5, 1904
SITUATION SEPT. 1
Scale
0 1 2 3 4 5 miles
RUSSIANS
JAPANESE
MAP L 4
San-chia-tzu
Pan-la-shan-tzu
Ta-ta-hen-kou
Ho-kung-pu
Yang-yu-chi
Kao-li-hang
III A.C.
I S.A.C.
XVII A.C.
X A.C.
3 D
2 D
12 D
4 D
6 D
5 D
10 D
3 D
G. D
11 K B
10 K B
29 K R
9 R
12 R
139 R
140 R
138 R
35 D
San-wa-tzu
Hei-yu
Tsao-fan-tun
Shi-ho
An-ping
Wei-chia-kou
Chi-ling-tzu
Chin-erh-tun
Pao-skou-kou
Shang-shih-chiao-tzu

action, the Russians did not cling steadfastly to their advanced positions, which were about three miles in front of their extreme (outer) intrenched line.

August 26. The battle of this day was almost entirely in the advanced and unprepared positions. When Gen. Kuroki gave his order, on the 22nd, for the battle on the 26th, he kept out no general reserve, but ordered the 29th Kobi Regiment forward as general reserve from the line of communications. This force arrived the night of August 25th in quite exhausted condition. The Guard Division commander, in his order for the battle on August 26th, retained only 1 battalion as his general reserve. Likewise there were small local reserves in each unit.

On the Russian side, we find 2 divisions as general reserve, being ⅓ of the army in that district.

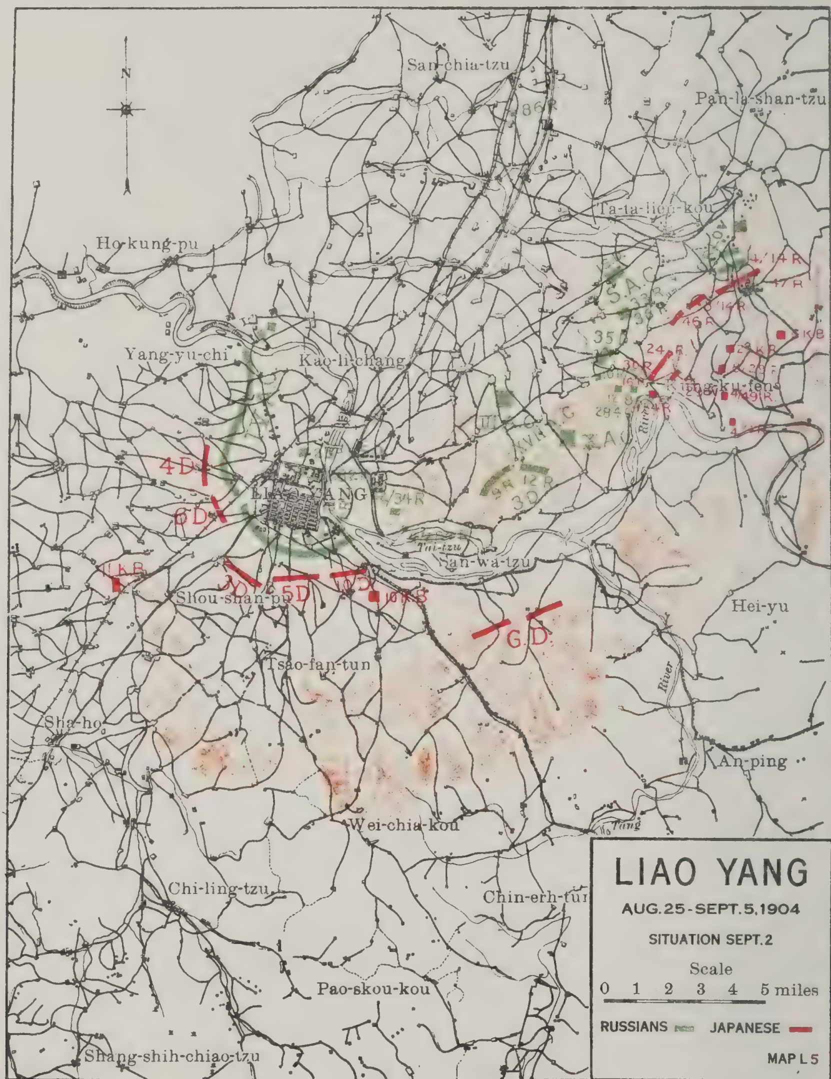
As a result of these dispositions, we find the following situation when the battle was at its height, August 26 (map L2) (omitting, this day, all reference to Gen. Kuropatkin's general reserve, and to the 2nd and 4th Japanese armies).

	Russians.	*Japanese.*
Not close enough for actual contact	0	0
Not at Points of Contact:		
35 Infantry Divisions (16 battalions)	10,400	
3 Infantry Divisions (11 battalions)	6,950	
At Wei-chia-kou (1 battalion)	650	
29th Kobi Regiment (2 battalions)		2,000
At Points of Contact	37,750	40,000
	55,750	42,000

It is thus seen (map L2) that the Japanese started the battle with 40,000 men against 37,750, retaining only a general reserve of 2,000 exhausted men, while the Russians had, about 12 miles away, an unexhausted general reserve of 18,000 men.

Although Gen. Kuropatkin had directed Gen. Bilderling "to assume the offensive, should circumstances be favorable," the latter, in his orders, showed no such intentions; and the Japanese did all of the attacking. (H154, 155.)

On the right, however, Gen. Bilderling did order 1 regiment of 35th division (140th regiment) to the center of line held by 3rd Siberian Army Corps. The remaining 3 regiments were ordered to Ssufangtai, some 8 miles in rear of the firing line. The 3rd Division was ordered to remain in its position, at the rear and north of the Tai-tza River.


N
San-chia-tzu
Pan-la-shan-tzu
Ta-ta-lien-kou
Ho-kung-pu
Yang-yu-chi
Kao-li-chang
LIAO-YANG
4D
6D
5D
G.D.
S.A.C.
35D
3D
Shou-shan-pu
San-wa-tzu
Tai-tzu
Hei-yu
Tsao-fan-tun
Sha-ho
An-ping
Wei-chia-kou
Chi-ling-tzu
Chin-erh-tun
Pao-skou-kou
Shang-shih-chiao-tzu
River
LIAO YANG
AUG. 25 - SEPT. 5, 1904
SITUATION SEPT. 2
Scale
0 1 2 3 4 5 miles
RUSSIANS
JAPANESE
MAP L 5

Briefly, the Japanese attack in the center, 2nd Division, made practically no progress. The Japanese attack on the Russian left, Guard Division, started an envelopment of the Russian right; but the 140th Russian Regiment changed its march to the right flank instead of the center of 3rd Siberian Army Corps, and the Guard Division was driven back in confusion. Its commander threw in all his reserve, and also called on Gen. Kuroki for more assistance. Gen. Kuroki replied that only the 29th Kobi Regiment was available, and it was so weary that it could not arrive in time.

However, the other 3 Russian regiments of the general reserve were still 8 miles away (and never did come closer); so the Japanese were not further routed.

On the Russian left, the Japanese 12th Division and Kobi Brigade fought desperately against the 31st Division of Russian X Corps, which force occupied a portion of the Russian prepared outer line of trenches. After throwing in its last local reserve, the left of the Russian force was driven out of a very strong position. Its commander had called, repeatedly, for reserves from the general reserve (the 3 regiments of 3rd Division, about 12 miles away) but Gen. Bilderling would not send any assistance.

Consequently, the Russian left was driven back at 6:00 P. M. (after an all-day battle). Two hours later, Gen. Bilderling consented to the use of the 3 general reserve regiments; but it was then too late.

That night the Russians decided to abandon all of their advanced positions, and this part of their outer, prepared and intrenched, position, and fall back to their first (outer) prepared line of intrenchments, omitting the extreme left which had already been captured by the Japanese.

It is thus seen that the Japanese kept out of the battle only 2,000 men, and these were too tired to be effective. The Russians kept out 15,000 men, being all but 3,000 of their original general reserve of 18,000 men.

As the Russians badly defeated the Japanese in one section of the field, and lost in the other by a very narrow margin, it seems that the use of only a small part of their 15,000 reserve could have secured a Russian victory on this day.

August 27. As soon as the Russians had fallen back to their outer prepared and intrenched line, they developed certain weaknesses in the line, showing that the left of the troops on the southern front would be exposed. Although these Russian troops on the southern front had, on August 26th, occupied the proposed outer

line and had not been seriously attacked, nevertheless, on August 27, about 4:00 A. M., they were told to withdraw.

Comment. There was nothing radically wrong in the location of this outer prepared line. If Gen. Kuropatkin had been active in its defense it might have been held. Only one-sixth of it had been taken, and the new sixth occupied was really more suitable for defense in view of the high water in the Tang River.

Gen. Kuropatkin might profitably have used, here, some of the 30,000 general reserve which he had kept back, and around Liao-Yang; but he decided to withdraw his advanced troops to his second prepared line. (Map L1.)

August 28. The Russians continued their retirement, and there were serious combats both on the eastern and southern fronts, but by nightfall of this day the Russians were in their second prepared line.

August 29. Both sides, generally, rested this day and prepared for the next day's contest. From the map, it will be seen that the following was the situation. (Map L3.)

	Russian. Bns.			*Japanese.* Bns.	
On Line or Local Reserve:					
I S. C.	24		6 D.	12	
III S. C.	24		3 D.	12	
283 R.	4		11 K. B.	6	
140 R.	2		5 D.	12	
X C.	32		10 D.	12	
			10 K. B.	6	
			G. D.	12	
			29 K. R.	2	
			3B/2D.	6	
		— 86			— 80
	(56,000)			(80,000)	
Specially Detached:					
XVII C.	26		15B/2D.	6	
284 R.	4		12 D.	12	
			2 K. B.	4	
			4 D.	11	
General Reserve:					
6R/25D/IV C.	4				
5 S. D.	12				
IV C.	23				
Liao Yang Garrison	9				
		— 78			— 33
	(50,000)			(33,000)	
Not too far away (available, 11,000)		17		0	
Garrisons, too far away (8,000)		12			
		193			113

It is seen, from the above table, that the Russian commander, on the fighting line, disposed 56,000 men against 80,000 Japanese. As a reserve, and detached for special work, he had 50,000, while the Japanese had 33,000. Of other detachments, the Russian commander had 19,000 men, of whom 11,000 could have easily been made available; the Japanese had none.

Assuming that Gen. Kuroki's turning movement (22,000 men) was to be observed by the Russian XVII Corps, and 284th Regiment, we find that, as general reserves, the Japanese had only the 4th Division (11,000 men) while the Russian commander had, still unused, 31,000 at Liao-Yang, 11,000 others available, and had wasted, elsewhere, 8,000, a total out of action of 50,000, as compared with 11,000 Japanese.

It must be remembered, however, that the Russian commander had great fear of a Japanese turning movement, and also that his staff estimated Gen. Kuroki's turning force at about double its actual strength.

August 30. All the fighting, this day, took place south of the Taitzu River. Gen. Kuropatkin reinforced his line, piecemeal, from his general reserve, and at the end of the day had only 19 battalions of general reserve, all south of the Taitzu (Q68). However, he had driven back the Japanese all along the line, and at the extreme west of his line had stopped the small Japanese reserve (4 battalions) which had been put into the battle. The remainder of the Japanese general reserve, 7 battalions, was not engaged.

On the extreme eastern front there was no fighting, as General Kuroki was moving to and across the Taitzu and the Russians were quiescent.

August 31. General Kuroki spent this day in getting to and across the Taitzu River with the 12th Division, Guard, Kobi Brigade, and half of the 2nd Division, leaving Guard Division to operate in conjunction with 4th (Nodzu's) Army. On the extreme west of the line, there was desperate fighting, the Japanese being repulsed. The Russians did not find it necessary to use their general reserve, and the Japanese were afraid to use their's (7th battalion) as they preferred to keep it available to drive back an expected Russian turning of their left.

In front of the Russian X Corps, it was seen that the Japanese were marching to the northeast, and General Vasilir proposed a counter-attack, but was told to send in to the General Reserve any

extra troops he had. Consequently, there was no fighting in front of X Corps, and very little in front of III Corps.

General Kuropatkin's staff estimated (L233, Vol. II) that General Kuroki's force north of Taitzu River was 65,000 to 70,000 men, whereas, when all of his troops were across, on September 3, its strength was, at most, 28,000 (probably reduced to 20,000 by all causes). On September 1, General Kuroki had crossed only 22,000 (probably reduced to 16,000 by all causes). Moved by fear of this force, General Kuropatkin decided to withdraw to the inner Liao-Yang line, hold it with fewer troops, and concentrate all available troops against General Kuroki's force north of Taitzu River.

He issued his order about 7:30 P. M., August 31. Map L4 shows new positions as occupied during the next 12 hours.

September 1. On this day the troops south of the Taitzu River were occupied almost wholly in preparing for the next day's battle. On the eastern portion of the line, especially at Manjeugama, there was severe fighting. A large part of the Russian Army was occupied in marching from the former positions, south of the Taitzu, to positions preparatory for attacking the Japanese north of the river. Some of the Japanese forces were also marching from the south bank to assist those on the north bank. Map L4 shows the positions this day. From this we tabulate the following (L233, F717):

	Russian. Bns.		*Japanese.* Bns.	
Around Liao Yang Defenses:				
IV C.	30		4 D.	11
5 S. D.	12		6 D.	12
122 R.	4		11 K. B.	6
124 R.	4		3 D.	12
2 B/6S.D.	6		5 D.	12
282 R.	4		10 D.	12
283 R.	4		10 K. B.	6
	— 64			— 71
	(41,600)			(71,000)
In Contact near Manjuyama, or close enough for contact:				
3 D.	12		12 D.	12
35 D.	16		G. K. B.	4
85 R.	4		15B/2D.	6
284 R.	3			
Orlov:				
2 B/54D.	8			
11 R.	4			
10 R.	1			
	— 48			— 22
	(29,200)			(22,000)

Marching toward Manjuyama, or in position to so march:

		Bns.			Bns.
X C.	9 D.	13		3B/2D.	6
	31 D.	8		29 K. R.	2
I C.	1 S. D.	12		G. S.	12
	1 B/9 S. D.	6			
	3 S. D.	12			
III C.	6 S. D.	6			
	1 B/9 S. D.	6			
	34 R.	3			
	284 R.	1			
		— 67			— 20
		(43,550)			(20,000)
Right Flank Guard		2			
Garrisons too far away		12			
		193			113

General Kuroki, in his orders, kept out no reserve whatever for his own use in the battle north of the Taitzu River. However, owing to the threatening attitude of the Russians around Coal Mines (Orlov's detachment, Map L4). General Kuroki's 12th Brigade and Guard Kobi Brigade were not actively employed. The rest of his force, 15th Brigade and 23rd Brigade, were active in the Manjuyama battle (F124).

The Russians held their position on Manjuyama during the day, but were driven off by a night attack. In the final attack the following was the disposition of troops close enough to be available for the night work:

	Russians.	*Japanese.*
	Bns.	Bns.
Actually engaged	5	8
	(3,250)	(8,000)
Close enough, but not engaged	21	4
	(13,500)	(4,000)

Comments. It is thus seen that Kuroki had about 22,000 men near enough to get into the fight north of the Taitzu River, while the Russians had about 29,200. In the actual fight, the Japanese won Manjuyama Hill with 8,000 against 3,250.

September 2. General Kuropatkin resolved to hold around Liao-Yang, and attack the Japanese north of the Taitzu River. He issued an order for routes of march to the eastern front, stating positively his intention to attack (I232, F717). The situation for this day is shown on map L5. From this, we tabulate the following:

	Russian. Bns.	*Japanese.*	Bns.
Around Liao Yang Defenses:			
		4 D.	11
IV C.	30	6 D.	12
5 S. D.	12	11 K. B.	6
122 R.	4	3 D.	12
124 R.	4	5 D.	12
2 B/6 S. D.	6	10 D.	12
283 R.	2	10 K. B.	6
	— 58		— 71
	(37,700)		(71,000)
Actually in Contact or Local Reserve:			
Orlov—			
2B/54 D.	8	12 D.	12
11 R.	4		
10 R.	1	2 D.	12
10R/3 D.	4		
35 D.	16		
85 R.	4		
284 R.	3		
	— 40		— 24
	(26,000)		(24,000)
Close enough for General Reserve:			
X C 9 D.	13	G. K. B.	6
31 D.	8		
I C 15 D.	12		
1 B/95 D.	6		
III C 35 D.	12		
65 D.	6		
9R and 12R/3 D.	8		
	— 65		
	(42,250)		(6,000)
Too far away for this day's Combat:			
Yentai—			
86 R.	4		
East of Liao Yang—			
34 R.	3		
284 R.	1		
Right Flank—			
Grekor	2	G. D.	12
34 R.	3		(12,000)
35 R.	3		
282 R.	4		
283 R.	2		
Distant Garrisons	8		
	— 30		
	(19,500)		
	193		113

The battle did not progress favorably for the Russians. Orlov's detachment, not having received its proper orders, attacked before the I S. Corps was ready to assist; was routed and driven from the field. The remainder of the Russian troops, except those near Manjuyama, did very little fighting, except in the trenches around Liao-Yang where some 37,700 Russians maintained their positions against 71,000 Japanese.

At Manjuyama itself, the fortunes were varied. In this locality the following troops were immediately available:

Russian.	Bns	*Japanese.*	Bns.
10R/3D.	4		
35 D.	16	2 D.	12
85 R.	4	24 R.	3
284 R.	3		
	27		15
	(15,500)		(15,000)
Close enough to be rendered available:			
X C.	21	G. K. B.	6
III C.	18		
	39		
	(25,000)		(6,000)

It is thus seen that the Russian commander could, at once, oppose 15,500 Russians to 15,000 Japanese; and, with proper use of reserves could, later, oppose 40,500 Russians to 21,000 Japanese.

The fighting was practically continuous here throughout the day, with two distinct assaults. In the first assault, made about 10:00 A. M., the Russians secured a slight foothold, but were unable to make any effective progress. In this assault the dispositions were (F141):

	Russians. Bns.	*Japanese.* Bns.
Actually engaged	6½	10
Local reserves	4	1
Close enough to be available	55½	10
	66	21

In the second assault, made about 7:30 P. M., the Russians succeeded in driving the Japanese from the west, but in the darkness were unable to push them off the eastern slope. In this assault, the dispositions were (F144):

	Russians.	*Japanese.*
	Bns.	Bns.
Actually engaged	26	9
	(18,000)	(9,000)
Local reserves	9	6
Close enough to be available	31	6
	66	21

Comments. It is thus seen that in the one case where the Russians assaulted the Japanese with superior forces they were successful. Even in this case, however, we find that the Russians held out as reserve, or at least failed to bring forward into the fight, a force more than equal to the one actually engaged in the assault.

September 4. General Kuropatkin prepared to continue the battle, but early in the forenoon, when his staff was preparing his orders, he received information which changed the whole aspect of affairs. (F151.)

A. The left of his line (I Corps) had retired about 2½ miles, without orders to do so.

B. The Russians who had taken the crest of Manjuyama had abandoned the position.

C. The commander of troops in Liao-Yang defenses reported that he was nearly out of ammunition, and needed more reserves.

General Kuropatkin decided to retreat to Mukden.

The Japanese pursuit was not very vigorous.

General Comments on Liao-Yang. On looking over the operations in this battle as a whole, we find that results might have been different under the following suppositions:

(a) *August 26.* If the Russians had thrown in their reserves (18,000 men) they might have won a victory in this part of the battle-field, because the Japanese had in reserve only 2,000 men and these were exhausted by long marches.

(b) *August 26.* If the Russians on their extreme left had thrown in the reserves immediately back of that portion of the line, they might have won a victory here, and surely would not have been driven out of their position.

(c) *August 30.* The Russians held their own this day. They had available, unused, some 50,000 men; the Japanese had available only 11,000 men, and some of these were put into the battle before

the day was over. If the Russians had put these 50,000 men into the battle, it is possible that the Japanese might have been defeated; it is certain that General Kuroki would not have had the hardihood to continue his very precarious turning movement.

(d) *September 1.* It seems evident that the Russians would not have been driven off of Manjuyama if they had thrown into the battle the 13,500 men close enough to be used.

(e) *September 2.* Considering the whole line north of the Taitzu River, the result, this day, may be called a drawn battle. If the Russians had used the 42,000 men who were available in this vicinity, they would probably have won, as the Japanese had, as reserve, only 6,000 weary men.

(f) *September 2.* Considering the battle at Manjuyama alone, it seems evident that the Russians could have taken it in the first assault if they had used all of their available reserve. Success here would have caused more favorable results elsewhere in the field, possibly preventing Orlov's defeat, and the halt of the I Corps.

GENERAL DISCUSSION OF RUSSIAN USE OF GENERAL RESERVE.

Noticing that it was the rule and not the exception for the Russian generals to keep out their reserves, we look for the reasons. We find the following:

(a) General Kuropatkin (Army Orders, August 15, 1904) said: "Keeping back more than half of the force in reserve is the best guarantee for success."

(b) General Kuropatkin, in his order dated December 27, 1904, said practically the same thing.

(c) General Kuropatkin was chief of staff to General Skobelev in 1877-78 (Russo-Turkish War). We find lack of co-ordination at Plevna (Balck 395), failure to use general reserves, and formation of many useless detachments.

(d) The Russian generals were nearly all veterans of 1877-78, and naturally followed the teachings of that war. The Russians had won that war, and their system seemed good to them.

(e) An authorized Russian text-book (1904) states: "In employing the general reserve, the commander-in-chief . . . should, in no case, use up his whole reserve before the decision has occurred."

OTHER HISTORICAL EXAMPLES.

The table below shows the uses of general reserves in other famous battles. The percentage of troops, stated in the table as "not actively used at critical moment," includes general reserves and such other detachments or large formed bodies which might have been actively used, but which were not so used. Officers may differ as to the critical moments of the battles under consideration; but it is thought that the tabulated results will be accepted by all as sufficient proofs for the conclusions drawn.

Battle.	Percentage of troops not actively used at critical moment	
	Victor	Vanquished
Auerstadt	0	30
Jena	0	0
Borodino	20	0
Waterloo	10	5
Antietam	0	27
Chancellorsville	14	42
Chickamauga	0	0
Cold Harbor	31	23
Koeniggratz	10	25
Gravelotte-St. Privat	25	15
Sha-Ho	15	30
Mukden	11	22

The circumstances governing the use of the general reserves varied in each battle, and the decision of the commanding general was influenced by politics, lack of information, etc. But, all things considered, the conclusions drawn from the above table are:

First. The great generals of history habitually used the general reserves with decisive effect.

Second. When, due to outside or unexpected influences, they failed to use the general reserves, the results were generally disastrous.

LESSONS.

It seems evident that no general rule can be laid down as to the employment of reserves. In some cases, it may be well to employ all the forces with a fixed object. In others, especially for defense,

it will certainly be best to retain a force for use in emergencies that cannot be foreseen.

Napoleon said:

> Dispense with nothing; a single battalion sometimes decides the day.

This principle is excellent for a genius like Napoleon; it is also excellent for any commander in any situation. The German ideas are found in the German I. D. R., which say:

> The reserve enables the commander to shift the center of gravity of the fight to the point desired by him, to reinforce his line where he considers proper . . . to bring about the decision.

The timely employment of the reserve is exactly that which distinguishes an able general from a timid one (who never employs it) and from a rash one (who employs it too quickly). As between the two, it seems preferable to employ the reserve too quickly than not to employ it at all.

Our regulations differ materially from the Russian view; they nowhere state that "keeping back more than half of the force in reserve is the best guarantee of success." They state nothing even similar to this; yet it is probable that our troops would often be as ineffectually handled as were the Russians. It happened in the Civil War; it may happen again.

Study of the details of the Russian battles shows that the supreme commander was not the only one who kept out a reserve. The next lower commander kept out a reserve; and so on down to the battalion commanders, and sometimes even the company commanders. Each kept out a reserve to provide for unforeseen developments.

The same thing may happen with the United States troops. Take, for example, the usually prescribed method of employing the troops in an assault by an infantry division. The attack will commence smoothly, with 16 companies (less than $\frac{1}{6}$) in the firing line. In a short time, the captains will call for reinforcements; the majors will send forward, say half of the battalion supports, and will call for reinforcements. A call may finally reach the Division Commander, viz, that "the battalion supports are nearly used up and reinforcements are necessary"—this, when less than $\frac{1}{4}$ of his men are fighting. A little later, he may receive another call, viz, that "the battalion supports are all used up and reinforcements are badly needed"—this, when less than $\frac{1}{3}$ of his men are

fighting. Later, and while the attack is progressing in an absolutely perfect manner, exactly as he expected, he may receive other calls. From colonels, "Regimental reserves nearly all gone; need reinforcements." Again, from colonels, "Regimental reserves all gone; absolutely nothing left. This, when less than ½ of his men are fighting. From brigadiers, "Brigade reserves nearly all gone." Again, from brigadiers, "Brigade reserves all gone; nothing left to protect my flanks." This, when only ⅔ of his men are fighting.

These reports are all exactly what may be expected; but in the turmoil, excitement, and horrors of battle, even a resolute division commander may become discouraged, and halt the attack. A very resolute commander will send his remaining ⅓ into the battle and clinch the victory.

Such resolution is the result of genius, experience, and confidence in himself, his troops, and the neighboring commanders. Genius is inborn, is rare, and can not be discovered in time of peace. Experience and confidence may be acquired, and the two are acquired by the same means, viz, study, maneuvers, and active service.

The lesson to be learned is the great necessity of experience in maneuvering troops. We have no active service. Some of us study; but no amount of study can inculcate the spirit of confidence throughout our forces. After sufficient experience in maneuvers, the majors will expect to employ their battalions without reserves, the colonels will consider it right and proper to employ their regiments without reserves, and the generals will acquire the habit of employing all of their reserves at the critical moment. Only thus can the commanders acquire the ability to use their reserves in the proper manner, viz, to bring about the decision.

THE COMMERCIAL WATERWAYS OF THE UNITED STATES

DEMAND FOR PROMOTING THEIR GREATER UTILIZATION

By

Col. John Millis
Corps of Engineers

In taking up this subject for brief consideration in its present phase of development it is conspicuously noticeable that the accumulation of voluminous printed matter, of arguments pro and con, and of reports, plans, estimates and commercial statistics still goes on and seemingly at an increasing rate. The mass is now almost overwhelmingly confusing in its extent and variety, and it would require a special talent in expression either to say anything new or to find an original way of stating what has already been many times repeated. We have reached the point where the demand now is rather for a conservation of words and a corresponding diversion of our thoughts and efforts to productive results, and the justification for the few remarks that follow is found only in the principle that even the most elementary statements seem to require reiteration again and again before they are absorbed in the public mind. Plainly and directly stated, the situation that now confronts the nation to the great embarrassment of the whole people is inadequate facilities for transportation, and an inadequate use of such facilities as do exist. These deficiencies are widespread, and the practical question before us is how shall this condition be remedied or at least ameliorated in the most expeditious and economical way. It is not a time for discussing this or that particular interest or for arguments based on the strife, rivalries and jealousies among different localities, on different methods of transportation, different enterprises, or different classes of the population. If it is possible that there should ever be a period in our history when internal contentions and competition can be laid

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[An address, delivered by Col. John Millis, Corps of Engineers, November 28, 1917, before The Atlantic Deeper Waterways Convention.—Ed.]

aside and when this great question can be considered by the general public in a new spirit of co-operation, free from undignified personalities and opprobrious references, and when it may be discussed solely on the basis of the greatest common good, we are surely in just such a period at the present moment.

While the activities of the Atlantic Deeper Waterways Association are directed more especially to the development of interior waterways along the Atlantic Coast, as stated on the cover of its monthly bulletin, its publications and the public utterances of its members, particularly those of its distinguished president, make clear that the interest and influence of the association are much broader and that the main title which I have chosen for this paper, The Commercial Waterways of the United States, is not inappropriate or too comprehensive. Indeed, the subject might be regarded as embracing to a considerable extent the waterways of neighboring countries, since commercial transportation does not altogether recognize international boundaries.

It is obvious to all that the question of every practicable economy and the highest degree of efficiency in every one of the numerous activities that make up the life of a great nation are now of special importance to this country. Among these activities *transportation* has a very conspicuous place. The shortcomings of the railroad system and the efforts being made to remedy these are just now much under public discussion, and this leads directly to the inquiry whether we are realizing to the fullest extent practicable all the possibilities of other means of transportation, including our great interior waterways. Commercial statistics in great detail and often with imposing totals which purport to answer this question are to be found in the official records, but to the average citizen these are often confusing and frequently not especially appealing. Certain very simple indications are probably much more significant to him than figures expressing quantities and values of commodities handled. Does he see on a navigable river or canal numerous warehouses and quantities of freight received or awaiting shipment? Are freight and passenger vessels actually plying on the waterway, and how many, of what size, type, and capacity, and how frequently? Are there general indications of development and improvement that might reasonably be expected in the vicinity of an improved waterway, like increasing population of towns and cities, new landings, new settlements, and enlarged clearings? Does he notice new factories and industrial establishments whose location

and construction seem to have been determined by the improved waterway? Or, on the other hand, are there evidences of general deterioration; abandoned farms, with residences, barns, storehouses and other buildings going to decay? Are there unusual landing places and wharfs, and the remains of wrecked and rotting vessels? Does he see real estate adjacent to available waterways or on the accessible waterfront of harbors which is advantageously located for manufacturing sites, warehouses, or terminal purposes, lying idle and undeveloped? And does he find the railroads and other routes of transportation in the locality overburdened, with terminals and stations congested with freight, and a general complaint of shortage of cars or other vehicles? Judged by these indications and regardless of what the commercial statistics show, it must be conceded that the observer would derive the impression in the case of some of our waterways and ports that have been constructed or improved at public expense that a greater utilization of their possibilities for commerce now demands serious consideration in connection with the whole problem of improved transportation facilities.

That there is room for very great improvement in the efficiency of the existing land transportation system is conceded and efforts to that end are now very active, but these only emphasize the demand for co-ordinate action as regards the ports and waterways. It is only fair to say, however, that some of the seeming deficiencies in utilization of the waterways for commerce are attributable to a failure to entirely appreciate their limitations in this respect. All rivers look more or less alike on the map, but they vary greatly in their adaptability for transportation. The rivers that have the staid reliable habits of the Hudson or the Rhine, or the volume and other favorable characteristics of the Mississippi, the Ohio, the Nile or the Danube, are the exception, and not all rivers—not even those that otherwise appear most attractive for commerce—happen to run the way commerce wants to go and insists on going. We shall gain much by recognizing at the outset the conditions in any particular stream or channel that are unfavorable; its direction, its crookedness, its swiftness of current, its variability in volume during floods and drought and in the level of its water surface, its obstruction by ice, the difficulties of constructing and operating landings and railroad terminals on its banks, etc. For the purpose of commerce these conditions must be considered in connection with the unquestionable advantages of land transportation routes in the way of reliability at all seasons of the year, the convenience and accessibility of stations, sidings and warehouses.

the easy connection with manufacturing plants, the speed of transit, and the apparent possibility of a more systematic organization and operation of a general transport system. A large part of the elaborate dissertations on the relative cost of transportation by land and water is of about as much practical value as would be a detailed analysis of the relative expense of taking one's family to church by automobile and in a buck-board drawn by a mule—while leaving out entirely questions of domestic expediency. The literature on the subject of the utilization of our waterways abounds in theories and discussions which attribute the deficiencies to the sinister influence of those interested in rival means of transportation, and we find instances of action by the state to force commerce to the waterways by means which are in a sense artificial, but I believe that one result of a more intelligent knowledge and sentiment that recent events have aroused is that these conditions can now be left to the patriotism of the people and a wise and liberal-minded statesmanship on the part of our legislators and administrative authorities, and that it will be practicable to secure the utilization of all available means and routes of transportation according to their respective economic advantages by a study of the commercial and physical conditions and by remedying or removing the physical obstacles to transportation. The several routes and methods that are not worthy of use on this basis will go *out* of use—and they ought to.

How shall we go about the needed readjustment? Like most other instances of progress in human affairs the process will probably be in a measure one of evolution; a yielding and realignment at first where the pressure is greatest, followed by corresponding changes elsewhere as may be suggested by the first experience and under intelligent supervision and direction. The prime requisite is first a systematic co-ordination and harmonizing of the means and facilities that already exist.

In respect to harbors a beginning has already been made in our greatest port, New York, by the recent appointment of a special commission acting under Federal authority to oversee and regulate all the activities and facilities of the port in order to promote the general efficiency. This example it is reported will be followed in other harbors, and something similar might be advantageous in connection with a greater use of the principal navigable inland waterways. One condition in our ports demanding especial attention is the removal of obstacles, whatever they may be, to the full utilization of waterfront real estate, especially where such real estate has been rendered available for waterfront purposes by im-

provement work done at public expense but where it still remains vacant and unused. For inland artificial waterways there is no better field in which to work out the numerous unsolved problems than that afforded by the enlarged canal system of the state of New York, and it will be advantageous for the Federal departments having to deal with these problems to keep closely in touch with the developments in this canal system—which it is expected will be generally available for use within a year or at most two years—and the incidental and contemporaneous developments in transportation on the Great Lakes.

The conditions of our river traffic proper present many variations and a uniform treatment cannot be applied to all these water highways, including the broad Mississippi and the Ohio with their great fleets of coal barges, the Hudson with its splendid swift passenger and freight steamers and the narrow, crooked and obstructed streams of the South Atlantic seaboard on which only comparatively small and shallow draft boats are practicable. The Great Lakes and their connecting rivers are in a special class by themselves, but for all our other interior waterways, except perhaps the wide bays and the larger rivers, the conspicuous problem demanding early solution is unquestionably that of the design of vessel best adapted to the channel, and its propelling power. This should receive careful study and if need be extensive practical experiment without delay. Some encouraging work in this direction has already been done under Federal authority, but the present is an opportune time to thoroughly thrash out this problem in connection with the unprecedented activities in vessel construction now prevalent.

In respect to the available vessels and the rolling stock, respectively, the status of the interior waterways and of the railroads is somewhat similar. The railroads have not now sufficient cars, locomotives and transfer facilities, or a sufficiently perfect organization and operating system, to render the full transportation service that the main line tracks are capable of. Likewise the waterways have not an adequate equipment of suitable vessels, with landings, warehouses, and freight handling conveniences to do the business that could be done with channels now available. Whether all these waterways would render the service expected of them if they did have adequate equipment should be tried out to the fullest extent, at least on several typical canals and rivers, as soon as possible; primarily as a measure of relief for existing conditions and with the ultimate object of determining in a practical way the

proper policy for the future in respect to the improvement and maintenance of these channels at public expense. It is not necessary to suggest that such a practical try-out on an extended scale of the waterways which we have—completing meanwhile important work already undertaken, especially the missing links necessary to make available waterway routes of considerable extent and maintaining the existing channels in an efficient condition so as to prevent natural deterioration—is of more immediate importance than undertaking entirely new enterprises of this character or a large extension of the existing system. It can be stated on competent authority that this is the view of our officials now in position of high legislative and administrative responsibility connected with public transportation.

Some reference to the importance of our waterways in connection with preparedness and military operations has been suggested and such reference will, no doubt, be deemed especially appropriate in this paper. Therefore let us recall the greatest possible utilization of the waterways is urgently needed at the present time as a relief for our transportation difficulties to the fullest extent they are capable of rendering such relief, in order to promote the most intensive and momentous preparedness enterprise that the nation has ever undertaken; a preparedness for the peace and well-being of all humanity for all time. And let us approach the problem, not in the attitude of belligerent defenders and champions of a cause which portions of our people have looked upon as unrighteous and as one inspired largely by local selfish interests, but rather "with the resolution and spirit of united action;" with the conviction that a wise and just solution will be in harmony with and will materially contribute to the ultimate working out of other questions of much broader import in human welfare and statecraft which already demand the attention of our ablest constructive minds. However bitterly we may execrate the present situation in international affairs, this sentiment must at least be credited with engendering in our country a widespread patriotism and national spirit, very numerous wholesome quickening activities, and many altruistic humanitarian standards and ideals. How shall the direct consequences of the horrible shock and catastrophe to civilization which we are now experiencing be healed and repaired, and how shall those beneficent and salutary results which it must be conceded are attributable to the present crisis be sustained and perpetuated, *without* the need of such an incentive as the possibility of the recurrence of a state of war.

RUFUS PUTNAM

By

Capt. Gordon R. Young
Temporarily Major, Corps of Engineers

Rufus Putnam's life is that of a typical representative of the class of men who founded our country and made secure its national existence. He was born to a most ordinary station in life, and was able and willing to earn his living at an ordinary trade; yet he had the ambition to prepare himself to be a leader in both peace and war, and the ability to assume leadership, when it came to him, with brilliant success.

He was born on the 9th of April, 1738, at Sutton, Mass., of a New England family which contributed at least one other notable name—Israel Putnam—to national history. The first thirty-five years of his life he spent for the most part at Sutton, New Braintree, and other Massachusetts towns, practicing the trade of millwright. During the French and Indian War, however, he enlisted in the army and served for three years (1757-60). He acted throughout in a subordinate capacity, being mustered out as an ensign; but he gained a valuable first-hand knowledge of war. His interest in military and engineering matters was aroused by this experience, and for some years thereafter he spent his leisure in the study of mathematics, surveying, navigation and the art of war.

In 1773 he was appointed a member of a committee to investigate some trouble that had arisen in Florida over land grants. No satisfactory results were attained by the committee. General Putnam, however, remained in Florida, and was appointed deputy surveyor of the province. It is probable, though there is doubt on the point, that he held this post for almost two years, returning north early in 1775. In the months preceding the Revolution he was active in support of the American cause, and in promoting the preparation for war. Soon after Lexington he joined the army, as a lieutenant-colonel in David Brewster's regiment. Here he quickly became prominent for his skill in military engineering.

The manner in which he prepared the defenses of Roxbury elicited great approval from higher officers—notably from Washington, who declared him to be the equal of any of the French engineers who were serving with the army. As a result of this success he was appointed, in August, 1776, to the position of chief engineer of the defenses of New York City. He rendered great service in planning and constructing these works. Congressional dissatisfaction, however, soon caused his resignation from the post.

During the remainder of the war he served in various capacities—as commander of the 5th Massachusetts, and later of two regiments of Nixon's brigade, in 1777, when he distinguished himself at the battle of Stillwater; as an engineer at West Point; as a colonel under Anthony Wayne, at Stony Point and afterwards. His work at West Point was especially notable; he was responsible for the selection of the place as a site for fortification, and in collaboration with his cousin, Israel Putnam, planned and executed the works which resisted the British until the end of the war.

In the years immediately following the Revolution he acted on several administrative committees, and was for a time a member of the Massachusetts legislature. During Shay's rebellion, 1786-7, he was on General Lincoln's staff. Shortly after he took up what was to be the most important and difficult work of his life, the colonization of the Ohio Territory.

This step had for some time been recognized as an important one, since it would interpose a barrier between the seaboard states and the Indian tribes, and would end any possibility of England's obtaining possession of the Mississippi Valley. Several plans had been proposed, but none had been found practicable. In 1787, in Boston, General Putnam organized the Ohio Company, composed of representative soldiers of Massachusetts. The object of the company was to arrange for the purchase of a tract of one and a half million acres in the Ohio Territory, and its colonization by veterans of the Revolution. General Putnam was elected superintendent, and through the agency of Manasseh Cutler, of Massachusetts, consummated the purchase in a satisfactory manner. There was some question at this time as to whether Congress would exclude slavery from the Ohio Valley, and it was due largely to the influence of General Putnam that this was done. Some years later, in 1802, there was a strong effort made to incorporate a slavery provision into the Ohio Constitution, which also was defeated by his efforts. Considering the influence that the states, afterward formed from

this section, would have had on the conduct and outcome of the Civil War, if they had been slave instead of free, it is safe to say that few more important services than this have ever been rendered the country.

Putnam, in person, led the first company of settlers across the Alleghanies in the early spring of 1788, arriving on April 7th, at the site of the present town of Marietta. The remainder of his life was spent in stabilizing the enterprise and building up the territory. He was at one time or another judge of the supreme court of Ohio, surveyor general, and commissioner to treat with the Indians. His success in the latter capacity was so great that he is considered to have, on several occasions, saved the colony from annihilation by disastrous Indian wars. He was instrumental in introducing the Ohio public school system, and in furthering the religious interests of the colony. His death, at Marietta, on May 1st, 1824, was in the midst of a great and prosperous commonwealth, whose greatness and prosperity were due in a greater measure to him than to any other man.

DEEP GALLERY SHELTERS

A Lecture

By

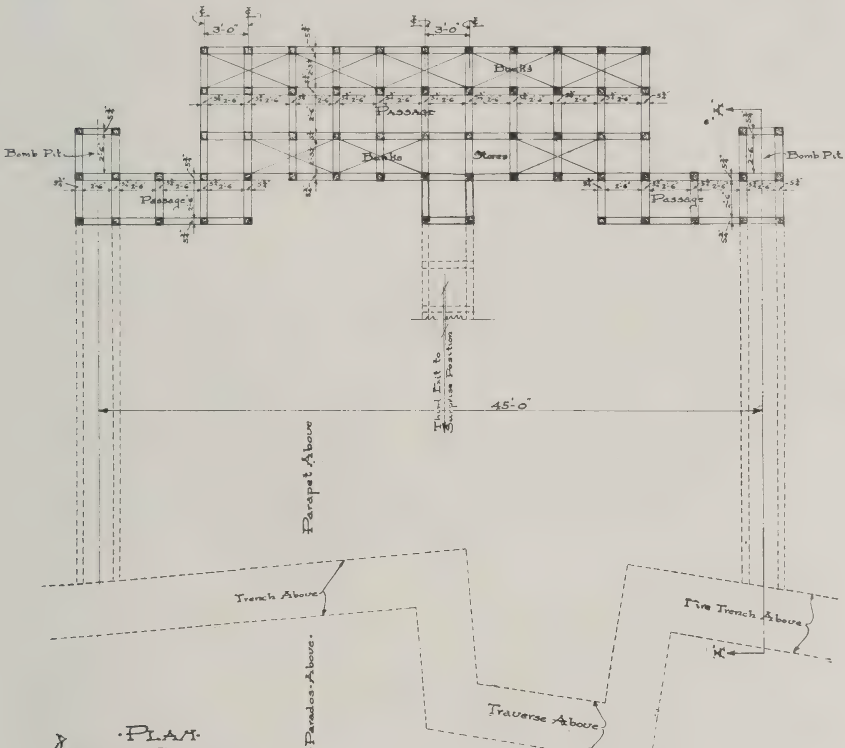
Col. P. S. Bond and Lieut. R. D. Leisk
107th Engineers, National Army

The nature of field works is naturally dictated by the nature of the weapons employed by both combatants, on the theory that the purpose of all field works is to allow the freest use of the weapons of the defender while restricting the use of the weapons of the attacker. In past wars and in the early stages of the present war, shelters constructed entirely above ground were common. They were, of course, easier of construction, and the problems of drainage, light and ventilation were not serious. It was soon found, however, that such shelters would not withstand the effects of high-explosive shells, the use of which has become so common; moreover, they could not be constructed without the enemy's knowledge.

The common procedure in the present war is to reduce the enemy's works to ruin and to shake his morale by long and continuous bombardment of heavy artillery, lasting for days and even weeks. When the works have been demolished and the enemy demoralized, the infantry assault is delivered and the works are captured. These operations are conducted continuously on a small scale, and at frequent intervals on a large scale. Men can not remain continuously in open trenches under modern artillery fire; yet they must be close at hand to man the trenches to oppose or deliver an assault. These conditions demand adequate shelters giving easy access to the fire trenches.

The use of these shelters by the Germans gave rise to the tactics developed by General Nivelle at Verdun. It was the custom to rain fire upon the enemy's trenches and at a given signal to suddenly lift the fire, whereupon the assaulting troops rushed forward to the enemy's trenches. During the time of their passage across "no-man's land," the Germans had opportunity to come out of their dugouts, man their machine guns, and oppose the assault.

This gave rise to what is known as the time-barrage fire. The French troops, instead of waiting until the curtain was lifted, would creep forward out of their shelters to the very edge of the curtain, and upon its being lifted would jump at once into the enemy's trenches and rush the dugouts. This resulted in their shutting up the Germans, or capturing them in their holes. These



·PLAN· ·OF· ·DEEP·TYPE·DUGOUT·

tactics are now employed by both sides and, accordingly, the need for adequate shelters with easy egress is greater than ever.

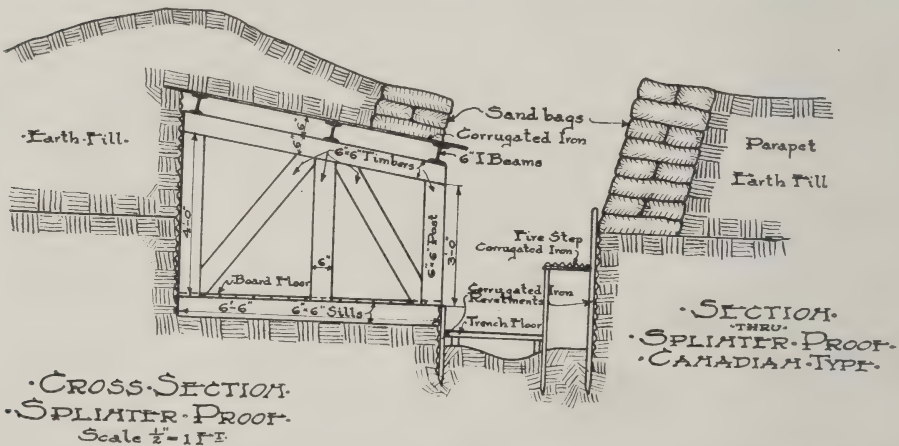
The shelter should generally be not too small, inasmuch as two or three outlets should be provided for each shelter, and if the shelters are small the relative amount of labor involved in the construction of the outlets is too great. On the other hand the shelters should not be too large, so that their capture or destruction or the blocking of their outlets would involve too large a number of men. They should generally accommodate at least 16 to 18 men, and

generally not more than 35. Special small shelters for dressing stations, observation posts and commanders' station will, of course, be provided.

In the earlier stages of the war a great variety of types was constructed. This was the experimental stage, but the construction of dugouts has now been quite thoroughly standardized.

This standardization in materials and methods is one of the most important developments in the art of constructing deep shelters. It is not absolutely rigid, but is analogous to standardization in building construction and has greatly promoted rapidity and efficiency.

The inclined shafts of the standard gallery have a clearance of



6 feet vertically and 2 feet 6 inches horizontally. The interiors are 6 feet high and 8 feet wide in the clear. This allows two tiers of bunks on each side and a passage 2 feet 6 inches wide.

Dugouts do not obviate the necessity for ample splinter-proof shelters in the front lines. The assault when delivered is so sudden that after there will not be time to get the men out of the caves. When the fire of the heavy guns ceases and the barrage of the light pieces is established, a large force of the men is moved to the fire trenches in preparation for the assault; while awaiting this they must be provided with splinter-proof cover in the front lines.

Slit trenches, about 18 inches to 2 feet wide and 7 feet deep, holding 12 men, are frequently placed at right angles to the approach trenches. They afford excellent shelter, except in the rare cases of direct hits, and it is much easier to get men out than from a cave shelter.

Dugouts may be divided into two classes, according to their mode of construction. One type is constructed by excavating from the surface over the whole area to be occupied by the dugout, "cut and cover." Timber frames are then erected, roofed over with logs or rails and earth or sandbags, etc., placed on the top of this until the required thickness is obtained. In constructing this type of dugout the roof may consist of successive layers of logs, rails, earth, brick and other material.

The other type of dugout is constructed by a distinct mining operation. A shaft must be sunk and rooms excavated without removing the ground above. These dugouts are usually called cave shelters. Both types of dugouts would be classed as bombproofs, in that they are designed to withstand the effect of direct hits by the artillery.

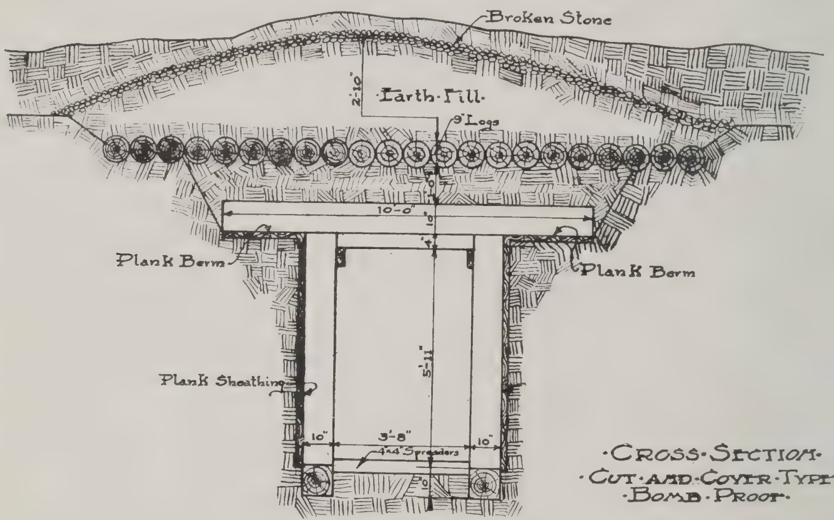
Regarding the use of the two types of shelter, the following recent communication from the War Department is of special interest:

> The question of shelters has become a capital one in preparing sectors, because of the increasing intensity of bombardments. As this bombardment is usually effected by medium and large caliber guns, it is absolutely necessary that shelters destined to protect troops be impervious to systematic and regulated fire of 150 mm. (6 inch) and to individual rounds of a 210 mm. (8½ inch) mortar. Experience has proved that shelters covered with logs and earth are unable to resist heavy shells with time fuses. Only shelters in mine galleries, called underground shelters or deep dugouts, can provide sufficient protection. Therefore they alone should be used.

This plainly indicates the growing tendency to abandon intermediate degrees of protection. Shelter in the fire trench, including overhead cover, is usually desired for protection against shrapnel or shell fragments, machine gun or rifle fire only. If more than this is required, it should be sufficient to resist direct hits of the heaviest class of projectiles ordinarily used for the destruction of such shelters, to-wit: 210 centimeter (8½ inch) high-explosive shell.

The lighter dugouts have been most generally used in the supervision trench just back of the fire trench. Here they serve the purpose of shelters for men when not on duty and during bombardment, and as dressing stations, command posts, and supply depots. They are usually constructed under the parapet of the cover trench. The construction of these shelters under the parapet of the fire trench is prohibited in most trench orders, as it weakens the parapet and a large number of such shelters will so honey-

comb a front-line trench that its complete collapse is almost sure to follow under a heavy bombardment. In constructing a bombproof with an artificial roof the minimum amount of cover allowed is that which will withstand the hit of a 3-inch shell, and wherever possible much more should be used. This minimum will consist of stout upright timbers, 10 by 10 inches or the equivalent, supporting a solid roof of 10 by 10 inch timbers laid side by side, on top of which will be 4 feet of earth with a bursting course of brick or broken stone near the surface, to detonate the shell before it penetrates too far. Many different designs are used in building these



bombproofs, but there are a number of general principles that apply to all of them.

The timber work should be at least four times as strong as is necessary to support the weight of the roof.

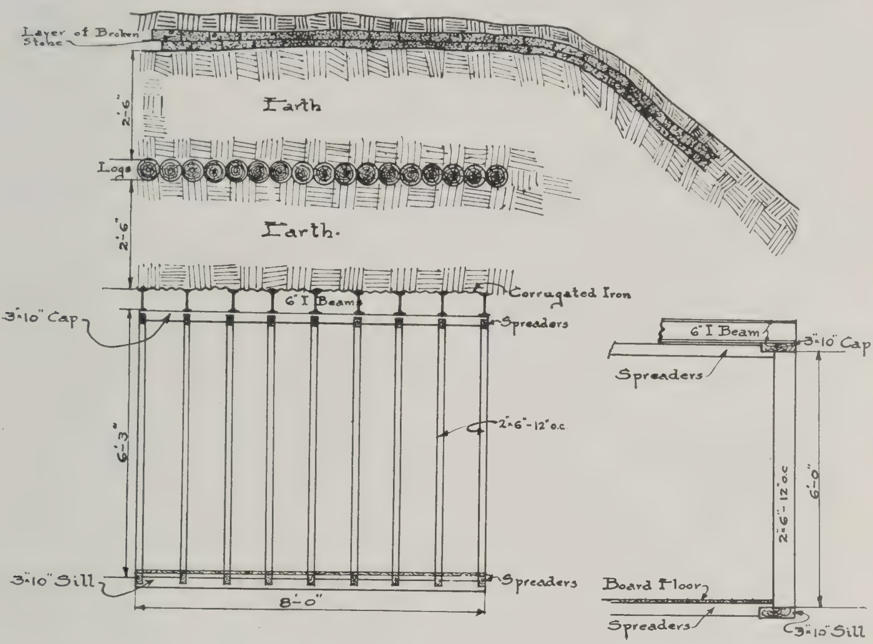
Upright posts should not rest directly upon the earth but upon horizontal sills. The same will be true of layers of rails or logs used in the roof, which should be supported at their ends and at intermediate points by stout frames.

A burster course of broken stone close to the surface should never be omitted.

Corrugated iron or tar paper is generally laid in the roof of such a dugout to make it waterproof, and sometimes this is helped by sloping the roof of the dugout.

[In some places] the dugouts are constructed with a sloping roof. The bombproof is designed to stop the direct hit of all

shells up to and including that of a 5.9 inch shell. Out of stores at the engineer parks standard frames are constructed. These consist of 3 by 10 inch caps, 3 by 10 inch sills, with 2 by 6 inch studding on 1 foot centers. These frames are set up in the excavation and spreaders are run across and tapped to catch both cap and stud. These form the floor and ceiling joist. On top of each stud is laid a 6-inch I-beam. On top of the beams corrugated iron is placed, on top of this 2½ feet of earth, a layer of logs,



·Minimum·Cut·&·Cover·
Bomb Proof
Canadian Type

2½ feet of earth again, and on top of this a layer of bricks or stone sprinkled with earth, as a detonating surface. A shell striking travels 1/100 of a second after detonation before it explodes. This means about 8 feet in air or 2 to 2½ feet in earth. Striking this detonating surface it explodes above the layer of logs, which distributes the shock of the explosion. The lower layer of earth acts as a cushion and the I-beams as springs, and in this way the structure takes up the blow of a direct hit. [It is specified] that in building these dugouts the span of the I-beams; *i. e.*, the distance between frames, shall not be less than 8 feet. The reason for this evidently is that the structure absorbs the shock of exploding shells

by its resilience, and the placing of frames too close together, while increasing the actual strength of the structure, would probably result in increased damage to both the frames and roofs. The minimum bombproof just described has been used extensively as cover for machine-gun emplacements, as company and battalion headquarters, advance dressing stations, advance brigade headquarters, report centers and observation stations.

The principal objection to the construction of deep gallery shelters on the front line has been the delay in getting men out of them in time to meet an attack delivered just as the barrage fire of the enemy is lifted from the front line. With all the dugout entrances or exits in the front-line trenches the dugout became a death-trap for the men in it if the enemy arrived in the trench before they were able to emerge. In order to permit leaving the shelter, even after the trench had fallen into the hands of the enemy, a third opening should be built, when possible, coming out in the rear of the parapet, in a shell hole, supervision or communicating trench, or some outlet other than the trench containing the two main entrances. This last exit should be carefully masked, and it serves also as a surprise position from which the men coming from the dugout can bomb the enemy out of the front line.

The advantages of the deep gallery shelter are numerous; the most important ones being the increased safety during bombardment and the fact that work on the dugout may proceed both day and night without interruption, something which is seldom true of the other type of dugout (cut and cover).

Cave shelters are readily constructed without arousing the enemy's suspicions, provided the earth is carried away without attracting attention. In the great galleries of the Messines Ridge the earth was removed in sand bags, generally by night, each man carrying one sand bag, and the operations were carried on for a period of nearly two years without attracting the enemy's attention. The work of excavating can be carried on and the sand bags filled by day as well as by night without attracting attention.

Enough of these dugouts should be constructed in each sector to shelter its garrison, which is generally calculated at one man per yard of front. The dugouts should be constructed in groups and should be interconnected. Each dugout should be connected by speaking-tube to a sentry post from which "no man's land" or the ground in front of the dugout can be observed, either direct or through a periscope. All dugouts must have at least two entrances, and if these entrances are in the same section of trench they should be far

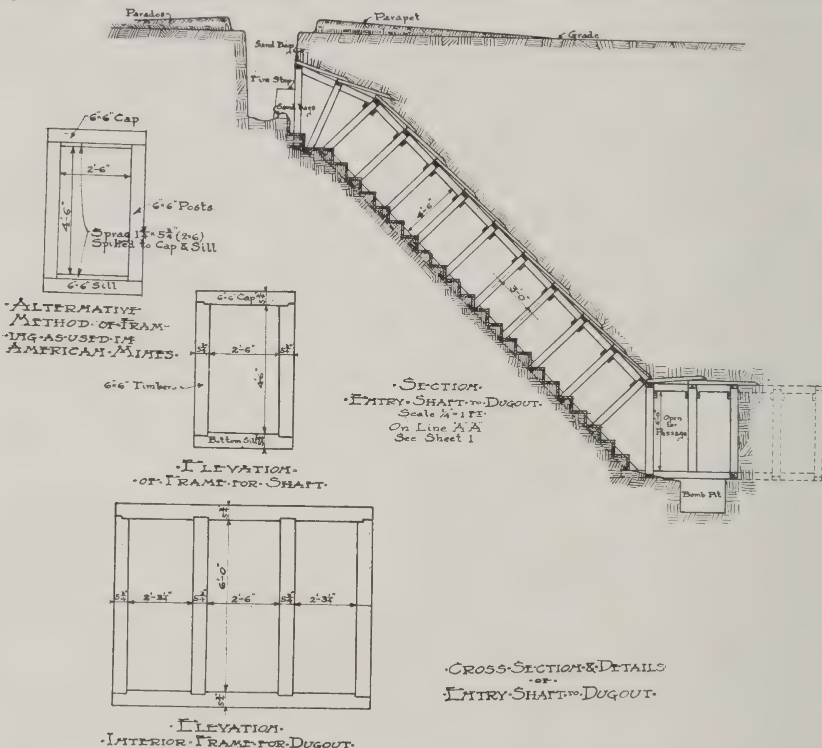
enough apart so that both will not be blocked by any single shell burst. They should be well concealed and, if possible, should be provided with good head-cover and a bursting course of broken stone. The top of the trench is usually strongly reinforced just above the entrance to the dugout. The entrances slope at about 45 degrees except in the case of dressing stations, where the slope is reduced to 30 degrees. The main gallery is generally under the parapet side of the trench, but at such a depth that the trench is not weakened by its presence there. When practicable adjacent shelters should be connected, but not in such manner that the destruction or capture of one would involve its neighbor.

Each shelter will contain double-tiered berths for a portion of the unit occupying it. These berths will be in the gallery forming the main shelter or in niches dug at right angles to it. The shelters will be supplied with hand grenades, excavating tools, ammunition, food, and signal rockets. A corner of the gallery will be reserved for the platoon or half-platoon leader. Chimneys will be constructed for heating, ventilation, or to allow the escape of smoke or gas. Provision will be made for the defense of the entrances and the protection of the gallery against grenades and asphyxiating gases.

There should be a minimum of 20 feet of virgin soil above the roof of the dugout. Where there are shell holes on the surface the depth should be greater. When the water level prevents reaching a greater depth reinforcements are placed on the ground above the shelter. These may consist of a layer of logs, cement blocks, bags of cement that have been soaked in water or bags of cement mixed with sand and pebbles and wet down (concrete).

A few notes on the constructional details of these dugouts will be interesting. The internal dimensions of the entry shafts are 2 feet 6 inches wide and 6 feet in vertical height. This will require frames 2 feet 6 inches by 4 feet 6 inches. These frames will be of 6-inch timber and will consist of a top and bottom sill and two posts shouldered and fitted. They will be put in at right angles to the slope of the entry and will be strengthened by distance pieces at the top and sometimes by diagonal struts from the top of one set to the bottom of the set next below. Frames will be spaced about 2 feet 6 inches apart. Wooden steps with 1-foot tread and 1-foot rise are provided. The interior of the dugout measures 6 feet high by 8 feet wide. It is timbered with 6 inch or larger material in the form of frames consisting of a top and bottom sill and four uprights. These frames are also spaced about 2 feet 6 inches apart.

Both entries and room are lined with 2-inch plank or corrugated iron. The inclined entries do not lead direct into the dugout. A short passage (about 3 feet) leading from the entry to the dugout is provided; and a bomb-trap, consisting of a pit deeper than the floor level of the dugout, is provided at the bottom of the entry shaft. Care should be taken to wedge all frames tightly, so that no play can develop. The last frame of the descent should be strongly



supported against the woodwork of the shelter. Sheeting and frames of standard dimensions are supplied from the engineer parks and are not, as a rule, made up on the site.

The question of drainage has been given much prominence, and with good reason, in the construction of trenches and dugouts. In the beginning little attention was paid to drainage, with the result that the trenches were often half full of water, the dugouts flooded and sickness from these causes very prevalent. The question of drainage is actually very simple. It should be remembered that water always seeks its own level and the lowest level possible. The water in any portion of a trench will accumulate in the low points

or depressions. If it be practicable to drain this away by gravity to a low point in the vicinity, the problem of drainage is usually solved. If this is not possible it must be led to a sump hole and pumped out. Where fire trenches, dugouts, etc., are built on slopes, surface ditches should be placed on the high side in order to intercept the water flowing down hill before it enters the trench. The entrances to dugouts should be so constructed that the water flowing along the trench will not seep through into the chamber. A roof in the dugout will, of course, prevent miscellaneous seepage and dripping of water from all points of the roof, and at the worst it will run down the walls if there is not heat enough to evaporate it. Finally, if the water gets into the dugout it will usually be impracticable to drain it off, unless the dugout be located on the slope of a hill and close to the surface at some point. Accordingly, a sump hole and some form of pump must generally be provided.

Electric or compressed-air drills are used when necessary to facilitate the work.

Special care is taken to provide for the exterior defense of these dugouts. Wire entanglements in front of the entrances are made especially strong and are well covered by cross-fire from machine guns. Bomb nets are placed to protect entrances to the dugouts. Means are also provided for the interior defense of these dugouts. This generally consists of the bomb-traps mentioned and obstacles to keep grenades from rolling into the main part of the dugout. As a protection against gas, blankets or curtains impregnated with neutralizing solutions are hung in the entries.

In excavating one of these dugouts both descents are begun simultaneously. Parties work 8-hour shifts and the descents are sunk at the rate of 6 or 7 feet a day. The rate of advance in the dugout is about the same. Each party during its eight hours excavates for and places one set of timber and casing. Earth is removed in sand bags or in small trucks running on wooden rails or in boxes sliding on the floor of the entry shaft. All precautions are taken to conceal the work from the enemy, especial care being taken in the removal of the earth. A dugout with a 20-foot roof and 50 feet between entries can be completed in 15 days.

Often the interiors are very elaborately prepared with artificial light, heat and ventilation desirable, if not absolutely necessary, features when it is remembered that soldiers and officers of many grades spend a large part of their lives in these subterranean dwellings.

USE OF CORRUGATED IRON FOR CONSTRUCTION OF SHELTERS

Translated from reliable sources
by

Maj. Henry Swift
Chaplain, U. S. Army.

In laying out lines for the siege of, or for the defense of, strong positions, there exists in corrugated iron a matériel of rapid utilization in the construction of communications or approaches, as well as of covers of every kind; for men, for ammunition and supplies, for flanking pieces, etc.

The corrugated iron employed is not proof against rifle fire, nor the fragments of a bursting shell, but it has a rigidity which enables it to sustain the weight of superincumbent banking, thus assuring the protection of shelters and their approaches against projectiles. Consequently corrugated iron should only be used in the main as sheathing, since of itself it does not afford sufficient security.

Corrugated iron material consists of:

Flat sheets of 2.80 m. by 1 m.,
Flat sheets of 1.80 m. by 1 m.,
Curved pieces with their accessories, these being of two kinds, of large or of small corrugations or waves.

Flat Sheets of 2.80 m.

Flat sheets of corrugated iron are designed to form the roofs of underground communications. These will serve to cover ways that are 2 meters wide at the surface. They are supported on each side by courses of beams, or where the breadth is not more than 40 cm. by the solid earth itself.

They are capable of sustaining, according to the degree of protection required, a covering or embankment (earth, sand, crushed stone) of 1.50 m. in thickness.

Flat Sheets of 1.80 m.

Flat sheets of 1.80 m. by 1 m. are used to cover underground passages 1.20 m. at the most. They are supported on each side by

beams, or by the solid ground where the width does not exceed 30 cm.

They can sustain, without inconvenience, a banking of from 2 to 2.50 m.

These flat sheets are also available for constructing walls for shelters, as well as for screens at their entrances.

SHELTER MATERIEL OF CURVED CORRUGATED IRON.

Type of Large Corrugations.

The matériel for shelters constructed of curved pieces of large corrugations or waves consists of:

Sections of arch,
Stringers,
Cross-beams,
Plates of galvanized iron,
Accessory matériel.

Arch Elements. The elements of the arch (Fig. 1) are of corrugated galvanized iron 3 mm. thick, with large trapezoidal waves 32 cm. broad, the height being about 10 cm.

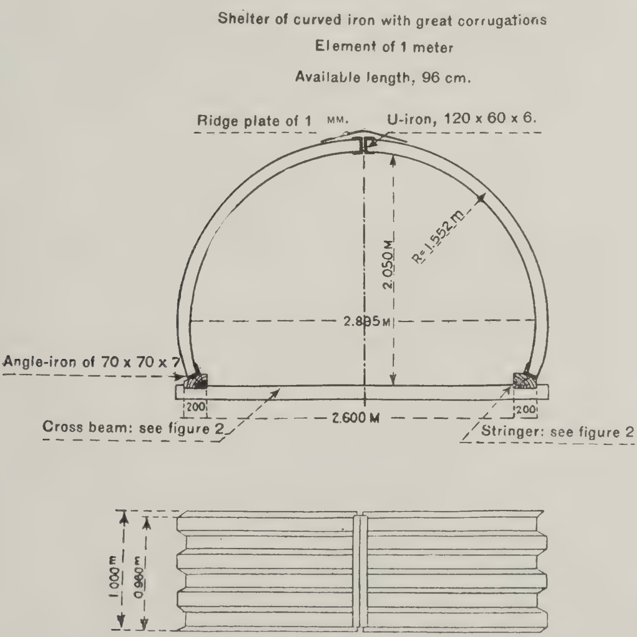


Figure 1

Each element or section is curved, following the generatrix of the waves, with an average radius of 1.60 m.

The dimensions of a section are:

Breadth, 1 m.,
Length of the chord about 2.49 m.

A section has three complete waves. Two elements are required to constitute an arch, set the one against the other so as to form a cover of about 2.90 m. in diameter and 2 m. in height.

Each element is provided at one extremity with an angle-iron of 70×70×7 pierced by three holes; at the other extremity by a U-iron piece of 120×60×6 fitted to the waves or corrugations.

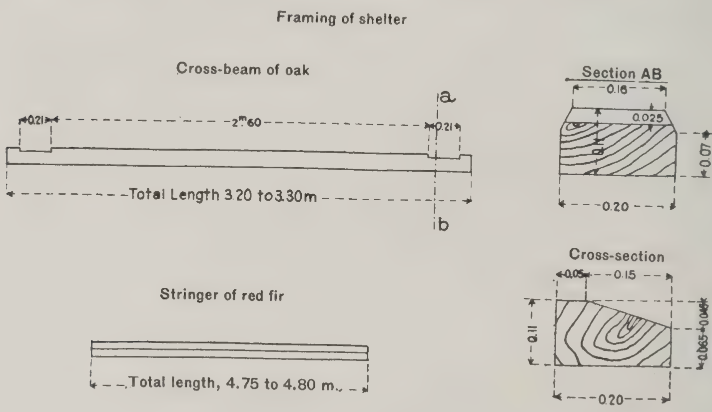


Figure 2

The angle-iron serves to secure the section to the ground; the U-iron serves as the key of the arch in connection with that of the second section forming the other side of the shelter. All of the sections are alike and interchangeable.

The available length of shelter made by the assembly of these two parts is about 96 cm. A section weighs on the average about 115 kg.

Stringers. The stringers (Fig. 2) are of fir, treated with creosote, 0.20 m. by 0.11 m., and 4.80 m. long. They are intended to serve as a base to sustain the sections resting in the angle-pieces at their extremities. Their weight is 55 kg.

Cross-beams. The cross-beams (Fig. 2) are of oak, treated with creosote, the dimensions being 0.20 m. by 0.11 m., and 3.30 m. long. They are placed across and under the stringers, which they support.

and whose spacing they maintain. For this purpose they have indents or mortises at their extremities, in which the stringers fit. Their weight is 70 kg.

Iron Sheets of 1 mm. These sheets of galvanized iron are 1 mm. in thickness, their dimensions being 0.60 m. by 2.00 m. They are designed to keep the shelter water-proof. They are placed on the cap of the arch, above the juncture of the range of opposing sections. Their weight is 8 kg.

Accessory Matériel. The accessory matériel consists of the small parts, fittings and tools needed for erecting the shelters. This is furnished in chests with cord handles, each containing:

2 Clamp-bars,
20 Three-hook clamps,
80 Pins, size 12 cm.,
45 Pins, size 6 cm.,
2 Ratchet-wrenches,
2 Machinist's hammers,
1 Locksmith's chisel.

Weight, 58 kg. One chest serves for 40 sections.

SETTING-UP OF SHELTER.

Lay on the ground (or rather on the bottom of the excavation) the cross-beams, being set 1 meter apart measuring from center to center, and arranging them perpendicular to the length of the shelter.

Set in the slots the two courses of stringers, the chamfered portions to the exterior.

Carry to the end of the run the first section (four men will be needed), the concave part toward the ground, the angle-irons placed on the right side. Attach this to the stringer on the right. Raise the section and stay it up provisionally, the U-iron being about 2 meters from the ground.

Set two bolts in loosely for the time being in order to attach the angle-iron to the stringer.

Bring a second section like the first, but with the angle-iron turned to the left. Set it exactly symmetrically to the first section. Adjust by the vertical faces of the U-irons the two sections against each other, after having fitted into their places the bolts with which the U-irons are provided. Complete the assembly by adjusting on the lower flanges of the U-irons a clamp of three hooks, which serves to prevent spreading.

The clamp is set toward the center of the U-irons, being set on the lower flanges, at first on the side with two hooks, which are ranged on one and another side of the notch on the lower flange of the U-iron, the single hook being at the corresponding notch on the other side. The clamp is then slid along a few centimeters until the single hook is clamped to its own flange.

If the U-irons are not snugly united, the clamp-bar is used, the jaws gripping the edges of the lower flanges (Fig. 3). The as-

Shelter of corrugated iron of large waves (corrugation) Details

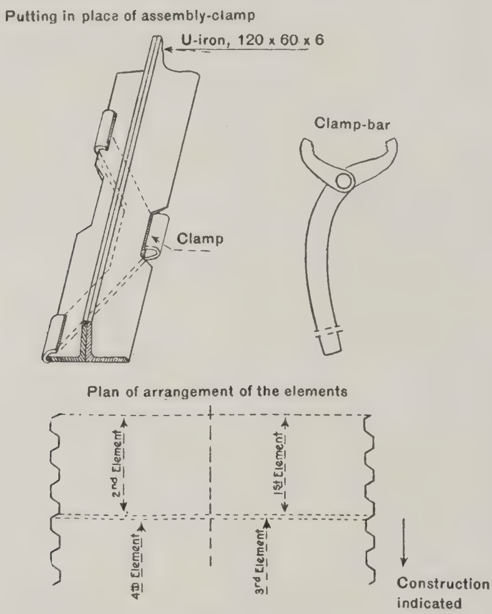


Figure 3

sembly completed, the bolts already attached loosely to the angle-iron are securely tightened home, and a third bolt is set.

The fitting of the other sections proceeds in the same order (Fig. 3), the section on the right being placed first—the observer is supposed to be looking toward the portion already finished—its rim lapping over that of the gutter of the last wave of the adjacent section. To do this it is necessary to place the element at first a few centimeters from its ultimate position, to adjust or dress it carefully, then to draw it back toward the exterior rim.

The sections having been set up, place over the junction of the U-irons a series of thin iron plates, 60 cm. in length, slightly bent

in V shape; these plates serve as a ridge piece, thus making the shelter water-proof.

SHELTER MATÉRIEL OF CURVED CORRUGATED IRON.

Type of Small Corrugations.

There is employed in the arrangements for the defense of certain places or positions a shelter matériel of corrugated iron, whose application is slightly different from that which has been already described.

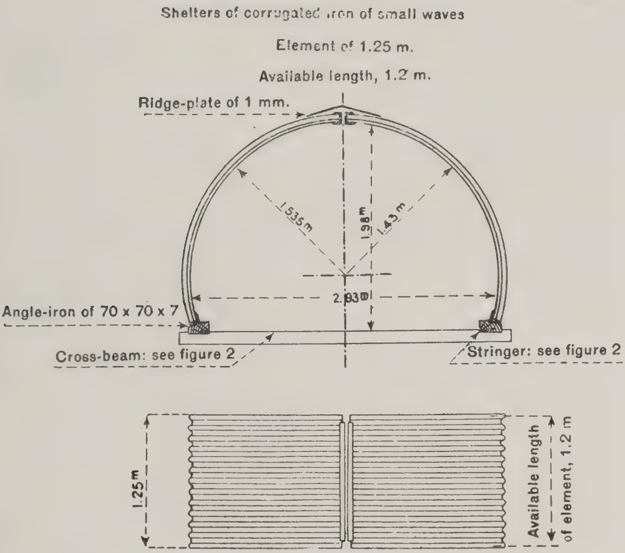


Figure 4

The sections are of plate 2.5 mm. thick (see Fig. 4), with waves 10 cm. wide and 7 cm. high. The available length of an element is about 1.2 m., and the weight of a section is 165 kg.

To permit the assembly of two consecutive sections, the extreme and contiguous gutters of the elements are—the one slightly expanded, the other slightly compressed, so that the latter may fit easily in the gutter of the other.

The sections are terminated at one and the other end by an angle-iron or by a U-iron. (See Fig. 5.) The assemblage of the two sections, when adjusted, is by pins which are riveted, and by 2 pairs of clamp-hooks which are bolted together.

The other disposition of matériel and adjustment are similar to that of the plates with large corrugations.

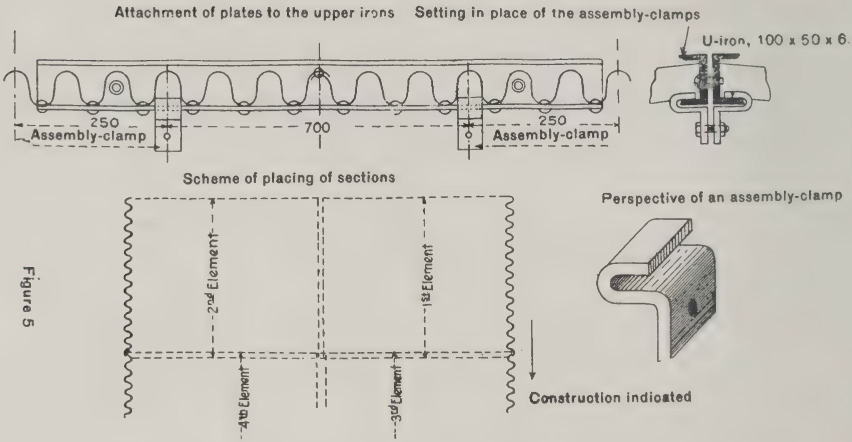


Figure 5

Shelters of corrugated iron of small waves. Details.

There is provided, for 40 elements, a chest of accessory matériel containing the following:

2 Clamp-bars,
40 Pairs of clamp-hooks,
50 Bolts,
1 Screw-wrench,
80 Pins of 12 cm.,
45 Pins of 6 cm.,
2 Machinist's hammers,
2 Ratchet-wrenches,
1 Locksmith's chisel.

Resisting Power of the Shelters.

Shelters of curved corrugated iron, embanked with earth, offer a resistance to shells with non-delay fuses in proportion, of course, to the amount of earth or other matériel superimposed.

A cover of 75 cm. deep at the key of the arch protects the shelter against the effects of an explosive shell of field artillery, bursting on the surface of the embankment.

A covering of from 1.2 to 1.6 m. assures, under the same conditions, an efficient protection against the effects of explosive shells of guns of from 120 to 155.

Capacity of the Shelters.

The shelters may be arranged either for men lying or sitting. (Fig. 6.)

Shelter for Men Lying (couchés). By installing double cots with an air space of 90 cm. beneath for circulation 3 men can be accommodated for every running meter of the shelter.

Shelter of curved corrugated iron; furnishing

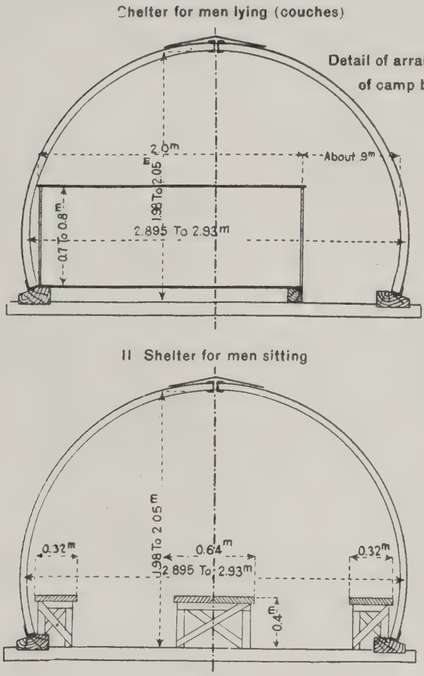


Figure 6

Shelters for Men Sitting. There may be installed 4 ranges of benches; a central double range, and ranges against the 2 walls of the shelter. The extreme capacity is 8 men to a running meter.

LIGHT SHELTERS OF CORRUGATED IRON, 1916.

Light shelters of corrugated iron are made by the combination of a certain number of sections of metal, 33 cm. in length and 1 mm. thick, each having 3 ridges. These elements determine the form of the figure as joined. On the interior side of the lateral faces (Fig. 7) are affixed 3 bands of metal (a), their ends being in form of a hook or claw. The weight of an element is about 10 kg.

Mode of Employment.

To form a shelter the sections are set side by side and fastened together by lashings of iron wire, these uniting the clamps of the bands (a) in order. The sections forming these shelters give of themselves only a slight degree of protection, but their rigidity permits them to sustain sufficient earth so as to increase their protective power.

The light weight of the sections makes it easy to transport them rapidly during the course of an engagement, and to improvise in a brief period of time little shelters over ground that has been taken from the enemy.

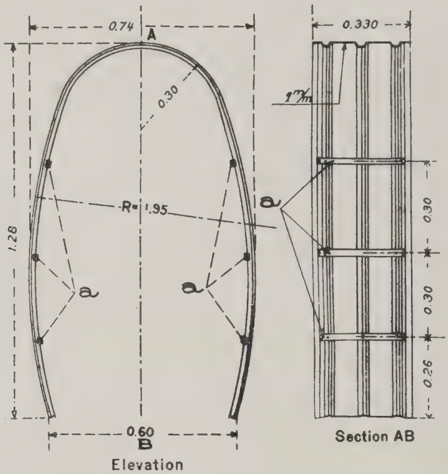


Figure 7

Large waves or corrugations give to curved plates a considerable resisting power against crushing effects, and to flat plates against flexion with a minimum weight of metal, surpassing considerably, if one would desire the same results by the use of plane sheets of the same thickness sustained by a framework of iron ribbing.

Besides this, in the latter instance there would not be the same facility of construction, nor the same immunity from leakage, as comes from the complete galvanization of the other and the absence of holes in the plates.

Matériel of small waves or corrugations furnish less resistance. For this reason the elements are provided with angle-pieces and U-irons, which reinforce them, while they facilitate their assemblage.

Before the war Germany only had rolling-mills capable of manufacturing these plates, which she employed as sheathing in the construction of water-tight galleries in some of her mines. In that country they could hardly fail to take note of the part this matériel might play in the construction of fortifications in resisting crushing effects.

Before the war France purchased this matériel by indirect methods, using it in the building of subterranean shelters in fortifications. Its application has become general since the war began, the shops of the allied countries having established the plants necessary for its production.

When the nature of the ground, or the presence of water renders the construction of underground shelters after the manner of mine galleries impracticable, the curved corrugated iron provides the best

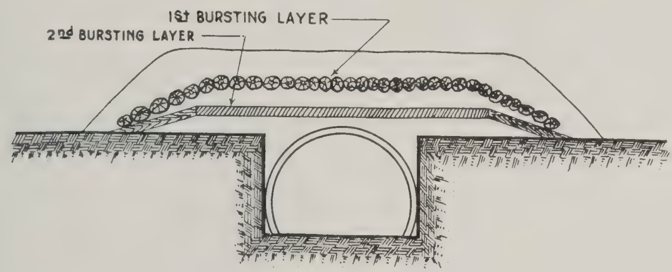


Fig. 8.

means of building shelters on the surface, rapid in the making, water-proof and comfortable, as well as capable of resisting the effects of shells from guns of medium caliber, provided there can be an embankment varying from 1.20 to 1.80 m. at the key of the arch, with auxiliary strata, with the interposition of 2 bursting layers (see Fig. 8).

The measures taken for the protection of entrances, as well as for drainage, are the same as for other kinds of shelters.

The ground floor of the shelter should have on it a layer of concrete.

This kind of shelter is very acceptable to chiefs of ambulance divisions of the first line; for in them they can have available working room under sufficiently antiseptic conditions, and where they can even perform major operations.

Where the shelter is in wet ground, and when the interior is heated, it may happen that by condensation the walls will sweat. This inconvenience may be rectified or diminished by the use of paint, if possible, a water-proof paint.

LIAISON OF DIVISIONAL ENGINEERS WITH THE OTHER TROOPS

By

Major Rousseau
French Army

I.

The term "liaison" has not quite the same meaning for Engineers as for the other arms. The other arms (infantry, artillery, aviation) will make the maximum effort at the climax of the battle, while the chief endeavor of the engineers will be exerted less during the fighting period than before, in preparing the attack, and after the battle, in organizing the conquered ground.

The prominent part of the engineers in actual warfare was not at first understood. Not only had trench warfare been unforeseen, but its possibility was denied; most authors of the highest repute preached a contempt for the "*couloirs topographiques*" a *fortiori* for the artificial and onerous "*couloirs*" of field fortification. French engineers had a very complete training in all branches of the engineer's duty, but very few chiefs and staffs realized how the engineers could usefully operate; many regarded them as a kind of infantry, marching and fighting with the others, at the same rate, and at the same time able to build as many bridges and as much field fortification as might be wanted.

The result of that conception was, in some divisions, the rapid disappearance of the engineers, already insufficient in number at the mobilization, since a division of infantry had only one company of 250 sappers.

The importance of field fortification increasing at the same time when the engineers were melting away, the high command gave orders to extend the recruiting[1] and refrain from the misuse of this branch of the service.

[This article results from a three years' practice with the French engineers, but, as to the distribution of the engineer troops for their various duties, the numbers prepared result from the American organization that has provided each division with 6 companies in lieu of the 2 companies of the French.]

[1]By picking up, from other arms, men and officers, susceptible of becoming

II. PART OF THE ENGINEERS DURING THE FIGHT.—LIAISONS.

The following consequently seems now to have become the rule:

Detachments of the maximum strength of a section, seldom of a platoon, shall be included in the waves of the attack, only to perform the tasks requiring special engineering skill; for instance, in the first wave, the rapid destruction of obstacles; in the following, the destruction of the dugouts or blockhouses wherein the enemy has intrenched himself; and in general of all things involving the use of explosives and special apparatus. The work for those detachments ought to be foreseen in the detailed plan of the attack, and their strength strictly adjusted for their task.

But the main body of engineers must remain grouped in units no smaller than a company, following, of course, the general movement, but far enough from the first wave to be out of the usual ebb and flow of the advance.

One part of that main body shall perform the very important duty of securing and repairing the communications leading to the first line, thus making possible the advance of fresh troops and of the artillery. These engineers shall be assisted by unskilled workmen, or old soldiers provided for that purpose.

The other part, the more important part, must be kept *in reserve,* in a proper situation to be readily brought forward to organize the conquered ground if the battle happens to get retarded.

Smaller detachments than a section may be used in the fight with efficiency; they must include very few men, from one to four, all volunteers, and eager to be distinguished.[2]

What will be the connections during the fight?

---

engineers. Every division receives a second company of engineers, a supply company, and a major for chief engineer of the division and the technical adviser of the general.

[2]Such squads, from one to three men, animated by the determination to get the War Cross, or merely to show to the infantry what engineers are able to do, have often done extraordinary deeds in the French Army. I saw not long ago, a lieutenant of infantry, leading a raid to the adverse trench in order to get some prisoners, chivalrously but in strict conformity with the truth, attribute the responsibility of success to one of two private engineers placed at his disposal. That man, with the help of the other, in a few minutes, cut the way in the common wire entanglement, pistol in hand, dragged behind him the whole detachment, blew up with explosives a blockhouse containing some enemies, jumped down into the first adverse trench, compelled two enemies to surrender, and helped, by his coolness, the officer to bring back the detachment safe in to our lines. The man, 42 years old, was quick and skilled in all engineer work. That chiefly had made him the lucky leader.

The place of the chief of engineers is in the post of command of the general commanding the division, or close to it.[3] Next, perhaps, to the commander of the artillery, he will be the man called the most frequently by the general. Besides, he should avail himself of the electric connections with the command-post to receive information or send orders to his subordinate officers.

The small squads or detachments placed at the disposal of the infantry during the fight depend exclusively upon the chiefs of the assaulting infantry.

No connection in general will be possible with the chief of engineers until after the battle, when they should give him an account of their operations.[4]

As for the operations of the main body of the engineers, the orders should be given before the battle for all foreseen work, but much unexpected work will be carried out by chiefs of battalions, and even of companies, without orders, without even reconnoitering, under the pressure of emergency; the chief of engineers will often become aware of them only by a summary account and demand of matériel. Nevertheless, provided with three regimental staff officers, he can easily secure his connections and reconnaissance.

One of his chief duties is to inform the general about the actual practicability of all regular ways and tracks on the battlefield; he shall have prepared the proper maps to transfer the informations thereabout as soon as received.

It can be easily realized how a quick and sure transmission of the latter is at all times in close connection with an efficient conduct of the successive stages of the battle.

The commanders of battalions and smaller units shall have also the maps and pieces of maps necessary to send quick and accurate information about the matter.

For the eventual organization of the conquered ground, the chief of engineers should have become familiar with it by studying in advance the maps of the ground where the results of the observation are transferred. He must be, at all times, able to submit proposals to the general, and to give indications to his subordinate officers about that subject.

[3]The immense dugouts built to contain the headquarters of the division during the battle, should contain underground rooms for the chief of engineers and his staff, not only to work, but also to live in, as long as the battle lasts.

[4]The chief engineer being charged with the preparation of the matériel and apparatus for the attack, assumes a share of responsibility, and consequently must be aware of the manner in which the matériel and apparatus have been used. Besides, the intervention of the chief of engineers may often prevent the detached men from being forgotten in the distribution of rewards after the battle.

III. PART OF THE ENGINEERS BETWEEN THE BATTLES, ON A PROVISORILY DEFENSIVE FRONT.—LIAISONS.

After the battle, some divisions are withdrawn to the rear for rest and reorganization, the others extend their front, reinforced sometimes by old soldiers and engineers.

The work must go on, either to reinforce the sector against attacks of the enemy or to fit it for the next offensive.

The chief of engineers will stay no longer in the divisional post of command, now settled in some village, or barracks, but at some distance, connected with the central telephone station in the headquarters, and through the same, with all other posts of the sector.

Let us suppose a division of two brigades, four regiments, holding a front of 8 kilometers with two regiments in the first line, two resting or in reserve.

A distribution of the divisional engineers might be:

One company coöperating with each of the 1st line regiments	2
Two companies working under the immediate direction of the chief of engineers	2
One company in various detachments coöperating with artillery, sanitary service, road service	1
One company in the rear resting or training	1
Total	6

This is merely an example, susceptible of great variations in reality, chosen only to review all possible cases of connection.

(*a*) *Liaisons in the zone where the regimental commanders are exerting a real and efficient authority*—

The commander of a regimental sector is indisputably responsible for the defense of that sector, and consequently of all works planned and carried out to improve the same within certain limits.[5] *What are they?*

[5]The duration and the character of the war have practically led to the formation of two kinds of armies; offensive armies formed in the rear with troops collected from the front and receiving a special training before starting a great offensive, and sedentary armies responsible for a defensive front, keeping it with a minimum of troops. The defensive armies have a fixed staff, some troops, such as heavy artillery, old soldiers and engineers, miners, if some mining warfare is conducted and sector services, like the map service, the information bureau, the road, water-supply and electric light services. But the divisions are not especially attached to one or to the other duty and are alternately included in both kinds of formations. Consequently, when keeping a defensive front, they must continue works often begun long ago, the initiative of all grades being limited to details and to facing emergencies—the staff of the army secures continuity in the execution of the plan of defense and supervises it through the chief engineers of the army corps and of the army.

A division occupying a front only temporarily defensive must carry out a plan of organization often prepared and always approved by a higher authority than the division commander. Within the division, for tactical reasons or for alternate rest and training, the same regiment will not always keep the same regimental sector. Therefore the best way of starting and conducting the work, is a close collaboration and agreement between the chief of engineers[6] and the superior officer, and finally the approval of the division commander, who should decide in case of disagreement.

That agreement will determine the order of urgency, discriminate the works assigned to infantry, regimental pioneers, and divisional engineers, or both at the same time; the durations, the emplacements for depots—and so on. (See Note 1.)

(*b*) *Liaisons in the zone where the engineers are working, under the exclusive direction of the chief of engineers*—

Usually in the rear of the intrenched zone of the 1st line are supplemental intrenched zones, named second, third, . . . positions, built to secure the inviolability of the front, if the enemy should succeed in taking by storm the first intrenched zone.

These positions, except in the neighborhood of batteries, are less exposed to bombardments, and are vacant or feebly occupied.[7] The chief of engineers is there able to carry out, under the best conditions, all the devices of field fortification. In those positions the trace of the trenches does not result from the hazards of the last battle, but from a careful preliminary investigation, in which the art of the military engineer can be given full scope. Concrete can be used, more powerful machinery employed to accelerate the digging, and a better organization for everything becomes possible.

Engineers can be helped, in all but technical work, by old soldiers, and sometimes by civilian workmen.

The connection of the chief of engineers with the division staff will consist in the reception of orders following the inspection trips of the general, in the sending to the headquarters of periodic ac-

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[6]Divided responsibility is one of the main features and difficulties of this war. The partition of responsibilities is no longer possible, on account of the complexity of the simplest operations. The men must get accustomed to very uneasy situations resulting from that fact.

[7]By machine guns in position, and very few troops, the remnant of the garrison grouped in camps ready for all contingencies, but living more comfortably than in the trenches and under a more immediate control of the officers.

counts with maps, and periodic lists of materials, tools and engines to be provided.

(c) *With the chiefs of engineers of the army corps and of the army*—

The chief of engineers, as a consequence of the footnote (No. 5) will, when the division occupies a defensive front, find engineer forces and services assigned to the ground. He will take command[8] of those engineers or may detach one of his adjutants for that object. Those forces and services will generally consist in detachments of the road, water supply, electric light, canton services; old engineers and soldiers used as auxiliaries.

As what is wanted is the further continuation of a general plan of work for all the branches above, as well as for the defensive organization proper, the chief of engineers may be required to give periodical accounts, through the proper channels, to the chiefs of engineers of the army corps and of the army. All the detachments and services above depend upon corresponding central services in the rear, for the reinforcement with men, apparatus and special supplies; with which the chief of engineers shall establish the proper connections.

Besides, the chief of engineers retains the initiative to instigate, in agreement with the division commander, all improvements to designs and changes in the order of urgency resulting from emergency, or from his experience.

SUPPLEMENTAL NOTES.

Note 1. Collaboration of the engineers with other arms or services—

Some skillful engineers may be placed at the disposal of the other arms to *help* them in the most technical parts of their work; that must never become a pretext for the latter to sit idle.

Often entire organic units of infantry will be furnished to engineers to perform all but the most technical part of the work. It must be an imperative rule to use them only under the command of their own officers and non-commissioned officers. The leadership of an untechnical work requiring a great number of men may be quite interesting and worthy of the officers' attention, as requiring a good

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[8]The general commanding the division takes the command of all sector troops used for the defense of the sector.

organization that influences enormously the final output. On the other hand, the engineers in charge of conducting the work should leave to the officers above all the initiative needed to get them interested in the work.

From another viewpoint, troops used as auxiliaries must never come to imagine they have become the servants of troops of another service.

Note 2. Most usual works of different arms and services in which the engineers may have to take part—

Artillery. Small dugouts for men and ammunitions close to the batteries, concrete casemates, observatories, camouflages.

Sanitary service. Dugouts, concrete floors, coarse furniture, painting.

Infantry. Dugouts, trenches in rocky ground, coarse house-carpentry for the dugouts and posts of command.

For all services. Cantons, barracks and accessories.

Note 3. Account—

The map service in the American army being committed to engineers, the chief of engineers will get all the maps necessary to study the planned works, and transfer the completed ones. In France "*plans directeurs*" on the scale of 1/20,000 and 1/10,000 are provided and sufficient for artillery purposes. But maps on the scale of 1/5,000 are wanted to transfer properly and show clearly all the details of a defensive organization. They can be obtained by a transfer to the proper scale of the conspicuous points of the map of 1/10,000, completed by summary surveys. They do not require, of course, the same accuracy as the *plan directeur,* especially prepared for the artillery practice.

To keep the map up-to-date, the chief of engineers will receive daily reports from the officers conducting the works.

[I recommend the use of written reports as little as possible, but of a double set of simplified sketches, going forth and back between the engineers headquarters and the chief places of work.]

If an important work is to be carried out in a fixed time, an accurate estimation of the total task ought to be made and a progress diagram prepared and joined to the scheme of the completed work.

Note 4. Liaison with engineers detailed to special work—

All the principles of connection stated above ought, of course, to be applied to special units of engineers, that might have to work

independently of the chief of the divisional engineers on some part of the front, although it is better that the chief of divisional engineers should take the command of all the engineers working in the sector occupied by the division. Those special units may, on a defensive front, be camouflage engineers or miners.

All operations of mining warfare are, by their very character, always interesting: for the defense that they may threaten; and for the attack that they may support.

In the latter case, they must often be in close connection with the operation, if the matter is for instance about the creation of large craters in order to take possession of some important point. The mining operation is then connected with a sudden attack, and consequently must be subordinate to the responsible commander of infantry.

Note 5. Echelonnement of the depots.

1st Line Depots—

Concealed or camouflaged as near as possible to the 1st line, supplied by the chief division engineer for a fortnight and operated by infantry in order to preserve the unit of command; but battalion engineers, trench artillery and all others working in the advanced zone get their material from these depots. From these places the material is usually packed by men (sometimes by burros or mules, seldom by 60 cm. gauge railway) to the places of work. Consequently these depots should be carefully located in order to minimize the transportation. Sometimes they are main regimental depots and sometimes secondary ones for battalions. Occasionally when an important engineer work is being built, a special depot will be organized by permission of the regimental commander.

2nd Line Depots—

Usually situated on the second intrenched zone and along the 60-centimeter gauge railway, ordinarily controlled by the engineers working under the direct command of chief engineers of the division. They furnish materials, tools, and engines to the 1st line depots, to artillery, to the sanitary services, and to the engineers building the second intrenched zone, and also to the road and water supply services.

Headquarters Engineer Depots and Shops—

Located, if possible, near a normal gauge railway station, and connected with the 60-centimeter railway, and under the direct

superintendence of the chief engineer of the division. They ship daily, by the 60-centimeter railway or motor trucks, the material wanted by the second and first line depots, keep account of all engineer supplies on the ground occupied by the division and are the quarters of the engineer regimental train.

Army Depots, Factories and Shops—

Situated near an important center of communication, in connection with the army staff; and usually under command of the chief engineer of the army. Some plants are hired or requisitioned, fitted and used for fabrication of military supplies. For instance, saw mills, delivering planks, boards, battens, grating; plants making portable barracks, gabions, camouflage materials; shops for repairing of engine and tools; portable shops on motor trucks are used for the repair of searchlights and motors. In France, the main part of these depots, factories and shops are usually under the command of the field officer commanding the army engineer train (*parc du Génie d'armée*), units drawn by horses, composed of a number of sections varying according to the importance of the army. [In America, I suppose they should be under the command of the colonel of the supply service regiment.]

The army depot does not receive all materials and supplies designed for the divisional depots. The transportation is minimized by wired orders sent to factories and depots in the rear, which ship the material through.

Note 6. Requests for material—

The regimental commanders, the commander of artillery, and the sanitary and quartermaster services send, once or twice a week to the chief of divisional engineers the list of engineering material wanted by their departments. The chief divisional engineer usually sends by the channel of divisional and army staffs to the chief engineer of the army on the 15th of each month the estimated list of all materials and supplies for the following month, and on the 13th and 28th of each month the requests for materials and supplies for the following fortnight; at any time, when needed, the unusual materials, or the materials requested for works, the erection of which has been called for unexpectedly.

The duty of the chief army engineer is to decide the urgency of the demands and to distribute the material accordingly.

Usually the 1st-line depots are provided for a fortnight, the 2nd-

line depots for a month, the headquarter depots for one or two months.

Note 7. Shops and repairs—

The principle of repairs is echelonnement. Every echelon repairs the tools and apparatus; items easily repaired with the means at hand and sends the others to the rear.

The regimental infantry pioneers are usually provided by engineers with a simplified blacksmith and carpenter equipment which enables them to make some repairs.

Some shops are built or hired near the engineer headquarters which are usually able to do the carpentry and joinery work, to shape extra pieces for machines and engines, to repair the special wagons of engineers, and make rough furniture for dugouts and command posts.

Note 8. Accountability—

It seems quite necessary that only the tools and apparatus included in the regular equipment of the infantry, artillery, cavalry regiments, and divisional services not attached to the ground, should be regarded as their property. All other apparatus, tools, and unexpendable material ought to be considered as lent, and remain engineer property, the accountability of the same being twofold; on one hand all the material belonging to the regular load of the engineer trains, on the other all the material required by the sectors. The latter is left in the depots, if the division is to be moved.

All main depots should have one or more clerks detached from the army supply regiment to secure the continuity of the service, and the guardianship of material if the division happens to be withdrawn or transferred to another front.

Usual Materials Provided by Engineers Besides the Regular Equipment of Their Trains.

Note 9. Wood—

Logs, timber, planks, boards, gratings, slabs for revetments, simplified gabions, battens, stakes, pickets and poles of every size.

Iron—

Flat, round, square, special sections, sheet iron; corrugated iron sheets for roofing; undulated iron sheets, arched or plain for bombproof shelters; wires of all diameters, worn rails.

Apparatus—

Mining warfare apparatus, shields of every kind, dismountable observatories, periscopes.

Building Materials—

Brick, cement, lime, gravel, broken stone, pavements, flagstones.

Electric Light Service—

Special tools and supplies.

Road Service—

Special tools and supplies.

Water Service—

Special tools and supplies.

Camouflages—

Constructed by the special camouflage shop of the army or by the divisional engineer shop when not requiring the special skill of the camouflagers of the army.

RAIL AND MOTOR TRANSPORT AS APPLIED TO MILITARY OPERATIONS

By

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Since his first appearance on this earth the development of transportation has been one of man's chief activities, if not the most important of all his activities. The progress of material civilization and the struggle up from barbarism are intimately connected with and reflected by improvements in transportation. The man who devised the first successful locomotive was as much an instrument of God for the uplift of the human race as those who founded the church, as without our transportation we would be barbarians living on nuts and husks and the proceeds of the hunt, unacquainted with what was going on in the world about us, poorly clothed and uncultured.

In those early days of our history every family reared its own habitation, provided its own food, made its own clothes and supplied all its own needs, utilizing only such of the materials of nature as were found in its own immediate locality. Eventually it was noted that certain communities produced certain commodities distinct from or superior to those of other communities. This gave rise to the trade or barter of commodities and ushered in the present industrial era. The interchange of commodities made necessary and stimulated the development of transportation, and today we find all civilized industrial communities the world over specializing along certain lines and shipping their products to all corners of the earth. In contrast to the primitive family which supplied all of its own needs we now see the modern family which provides none of them. The family is still the social unit but it has ceased to be the industrial unit. Each family is entirely dependent on the community in which it resides and the community is in turn dependent on the outside world. To such a point has industrial specialization been carried that not even so large a unit as the nation supplies all of its own needs; a fact which has recently been painfully impressed upon us.

The progress in the art of war, like the progress of material civilization, is directly reflected by the advances in the art of mechanical transport. From individual combats by savages armed with clubs, man advanced to the communal stage in which tribes banded themselves together for mutual protection and the plunder and conquest of their neighbors. Until comparatively recent times an army, so called, was a mere handful of professional fighters, paid usually in loot and booty. It was their custom to maintain themselves on the country in which they happened to be, whether friendly or hostile, and foraging was perhaps the most important feature of their military operations, certainly the one in which they displayed the greatest efficiency.

It is the progress in the art of transportation which above everything else therefore is responsible for the great scale on which war is waged in these days.

In modern war the theatre of operations is in almost every case inadequate to supply the needs of the army, whose military operations moreover cannot be interfered with by the necessity of foraging for their own sustenance. It was the Romans who first appreciated the important bearing of transportation upon military operations, who first realized the tremendous advantages which a line of communication gives to an army in the field. The result of this appreciation was the magnificent system of roads which the Romans built in their own and every captured country, and the transportation facilities thus provided were the secret of the Roman conquests, a secret which all might see but which few appreciated.

Battle tactics and transportation systems have changed since the days of the Romans. We no longer require what was formerly known as the military road such as the Romans constructed. In these days the long hauls of both troops and supplies are made over the railroads. The modern battle resembles the battle of ancient days, however, in one important particular—it is won by concentration of force.

It has often been stated that the fundamental principles of the art of war are eternal. The first of these principles was well expressed by General N. B. Forrest who stated that the battle is won by "he who gets thar fustest with the mostest men." In fact, success rests with the combatant who can most rapidly concentrate his force in men and munitions at the critical points. Formerly these rapid concentrations were executed by stealth, the enemy being held at bay and prevented from seeing what was going on behind

the opposing lines. Today with the hostile aeroplane hovering overhead, with the elaborate systems of espionage which are in use by all nations, and in view of the tremendous scale on which such operations take place, concealment is no longer possible and great speed in concentration must supply the element of surprise so necessary to success. The present war, and all future wars, will be won by the combatant who can most rapidly concentrate his men and materials. The issue will be determined by a staggering preponderance of men, money and munitions.

The world has been greatly interested in the startling innovations in the way of machines and methods that have been introduced in the present war. As a matter of fact, however, the effect of innovations is not as great as is ordinarily supposed. The most important weapons used in this war had been developed to a very high state of efficiency prior to the war, and the majority of them, even flame throwers, gas bombs, etc., had been used in previous wars. Many other devices such as the tanks, have been spectacular and effective in a local way, but have had no very important bearing on the general course of the conflict. It is simply that these machines have been used on a hitherto unprecedented scale. Two machines have been utilized in this war which were not used to any appreciable extent in any previous war and have resulted in revolutionizing its operations. These are the aeroplane and the motor truck, of which the latter is the more important, though probably the less spectacular of the two.

There is nothing dearer to the American heart than the hope of getting something for nothing. Many of us still entertain the delusion that one of our inventors will devise some machine or method which will enable us to evade the necessity of sending men to war. Military men realize that such a hope is vain. In spite of the best thought of the best minds in the world, the present war in Europe has developed few innovations which are startling to the military men. Battle tactics and weapons are not new, they have merely been more highly developed and employed on a larger scale than heretofore. War will never be won by any clever invention. Such devices have indeed been effective as surprises, though few of them can be dignified by the term "new arms of warfare." All have had their crude prototypes in former wars. Any new or effective machine that is invented soon becomes the property of all combatants. Thus in spite of the secrecy with which Great Britain guarded its tanks, their design was known to the Germans, and

when the tanks first appeared on the Western Front the Germans had already devised tactics for defense against them. No combatant can hope to have a monopoly of such machines and America will never win the war because she invented the aeroplane, the machine gun, the caterpillar tractor. She can only win if she is prepared to smother her adversary by a vast preponderance of men, materials, and machines of all kinds.

It is the steam railroad and the ocean-going steamship that are primarily responsible for the aspect of modern warfare and the vast scale on which it is waged. The cardinal principle of warfare today is that the nation must throw its whole strength into the conflict and that victory rests with the combatant who can most rapidly and effectively bring to bear the resources in men and material, not only of his own nation, but of his allies and all the peoples of the world from whom he can purchase. It is by means of the railroad and steamship that these resources are brought to bear. Motor and wagon transport are indeed of great value as accessories in the rapid distribution of men and material to the battle fronts where they are employed, but the long hauls by which resources from the uttermost ends of the earth are assembled for battle must be made by water and rail.

Well would it have been if the steam locomotive, the ocean-going steamship and the internal-combustion motor could have been confined solely to the peaceful pursuits of industry, science and society, but it was not to be; the War God saw them and wanted them and adapted them to his own particular needs. He does not play his game with hordes of men alone but uses great fleets of vessels, locomotives, motor cars and aeroplanes, all driven by the forces of nature which he has harnessed to encompass the destruction of his enemies. Because of transportation war has become more barbarous, more efficient, more interesting.

Some idea of the amount of supplies demanded by an army may be formed when it is remembered that a division consists in round numbers of 27,000 men and 9,000 animals. One day's rations for the men alone would weigh 35 tons and for the animals 110 tons. To transport the food allowance alone would require a fleet of 75 2-ton trucks. An army of 2,000,000 men, such as we intend soon to put on the European front, would require 6,000 2-ton motor trucks to haul its daily allowance of food alone.

The average expenditure of ammunition by the allied armies on the Western Front is in the neighborhood of a million rounds a

day. During the coming year, with the American Army in action, it is probable that this amount will be nearly doubled. The average weight of a round is in the neighborhood of 20 pounds, making a total of 20,000 tons of ammunition which will be expended daily by the allied armies on the Western Front. For the transportation and distribution of this ammunition 10,000 2-ton motor trucks would be required. Vast quantities of miscellaneous supplies of all kinds greatly increased the amount of transportation. Thousands of troops are moved back and forth from the front daily, requiring even more elaborate transportation facilities than for the movements of supplies.

The daily circulation is of course unprecedented in time of peace On one national road of France (The Bray-Cappy) which in peace times carried 150 vehicles per day, transportation on July 25, 1916, was as follows: 2,000 automobile trucks, 500 light automobiles, 6,500 horse-drawn vehicles. On all the large roads in the vicinity of Paris from two to three thousand cars move daily.

The difference between war and peace conditions will cause a wide departure of military from civil railroad practice. Some of the conditions of military railroad service are:

(a) Quick results for a short period are the first consideration.

(b) The mechanical possibilities of the property can not be fully developed, by reason of an untrained personnel.

(c) Speed requirements are moderate and practically uniform for all traffic.

(d) The roadbed and equipment are subject to damage beyond that resulting from the operation of the road, from the elements, or from decay. A civil road is operated on the presumption that the track is safe; a military road must be operated on the presumption that the track is unsafe.

(e) The property will usually be in fair but unequal condition, often hastily restored after partial demolition. The operation of the whole will depend on the condition of the worst parts.

(f) A military road is best operated with an ample supply of motive power and rolling stock, and a moderate speed; whereas on a civil road the tendency is to increase speed to economize rolling stock, and to increase train loads to economize motive power. The known ratios of equipment and mileage on civil roads cannot be taken as sufficient for military roads.

The old system of a few main line railways and horse-drawn vehicles cannot meet the demands of modern warfare. Were we to

depend upon such, an enemy equipped with a good railroad system and an ample supply of motor trucks would quickly overwhelm us. An examination of the maps along the frontier between Germany and Russia plainly indicates the advantage Germany possessed over her adversary. On the German side of the frontier we find a carefully prepared network of railroads, both parallel and perpendicular to the frontier, all designed for the very purpose for which they are now employed. On the Russian side we find a few railroads built without any systematic plan of efficiency. The result of a clash on this frontier could hardly be in doubt. The Germans were able to supply their troops with an ample quantity of munitions, whereas the Russians suffered under great disadvantages due to difficulties of transportation of their supplies. The Germans were able rapidly to withdraw troops from one point and concentrate them against another, which tactics the Russians with their inadequate railroad facilities could not possibly meet.

The operations of the supply of an army in the field are as follows: A number of points in rear of the line, having ample communications by rail or water with the producing districts of the home country, are selected. They should be sufficiently far to the rear to afford ample security from hostile incursion. At these points are established storehouses for materials of all kinds, barracks or cantonments, remount depots, repair shops, etc. Such points are known as base depots and to them are shipped the supplies of food, ammunition, forage, medical and surgical materials, and all other kinds of equipment as well as men and animals. From the base depot to the troops at the front supplies and reinforcements travel over what are known as the lines of communication. The greater the number of lines of communication possessed by an army the better. Generally there should be several lines for each depot.

For convenience in the movement of troops there are established mobilization stations, junction stations, etc., whence the men and animals from certain districts are assembled and distributed to the front in a manner similar to that followed in the case of supplies.

A division is usually detrained at at least three different railroads, in order to avoid confusion.

Shipments are usually broken at the base depot and the supplies of each class are stored in the appropriate places ready for distribution. Rail communication is usually established as far to the front as practicable. Since railroad transportation only is effective for very long hauls, the longer the haul by rail and the shorter that

by motor truck the more efficient, as a rule, will be the services of supply. The most advanced point for railroad transportation is known as a "rail-head" and here is established what is known as an advance supply depot, which is maintained as close to the rear of the army as is tactically and otherwise possible, whereby the number of animals, wagons, and motor trucks which clutter the rear of an army is reduced to the minimum. If rail-head is not close in rear of the battle lines, refilling points are maintained by means of a fleet of motor trucks. Ammunition is distributed in great piles convenient of access for the artillery. These piles are commonly known as shell dumps. From the advance depot or refilling point supplies are hauled to the point of direct issue to the troops by animals or motor vehicles. That portion of the line of communication between the advance supply depot and the line of battle is known as the zone of the advance.

The carriers employed between the base depots and the producing districts of the home country are usually commercially operated under such military control as may be necessary. Between the base depot and the line of battle the carriers are either operated or directly controlled by the government.

It will thus be seen that the relays and carriers in the typical case would be as follows: From the producing districts to the base depots, rail or water routes, commercially operated under government control: From the base depot to the advance supply depot, rail-head or refilling point, rail transportation operated by the Government: From rail-head or refilling points to issue points motor transportation pertaining to the line of communication: From the issue points direct to the troops, motor or wagon transportation attached to the organizations serving in the first line. In many cases large fleets of motors are maintained for transport over a considerable distance. Thus many fleets of motors operate from Paris to various points on the French front, but in general rail transportation under even fair conditions is to be preferred for long hauls, and motor transport for subsequent distribution.

The greatest difficulty encountered by the railroads of this country is that of terminal congestion. Military control and the nature of military traffic should greatly reduce this congestion if control is placed in the hands of competent officers. The shipments are more uniform in their nature, the amount to arrive is well calculated in advance, classification and storage is simpler and military control if properly exercised should greatly facilitate the

loading, dispatch and unloading of supplies. In any campaign in the United States it is probable that our railroads would prove to be adequate so far as the actual transportation facilities were concerned and the greatest danger would be a congestion at the terminals which might be avoided by intelligent arrangements in advance.

The weakness of a railroad as a means of transportation for either troops or supplies is principally the difficulty of terminals, that is to say, the time required to assemble men and supplies at the point of entrainment and to unload and distribute them at rail-head. It has been found by experience that for large bodies of troops movements of forty miles or less are usually made as quickly on foot as by rail. It is a question of balancing the terminal delays against the speed of transit between terminals.

The establishment of base and advance depots on the lines of communication insures systematic movement of supplies and prevents, first, the rushing through of excessive quantities of certain supplies to the extreme front while needed supplies of other classes are neglected; second, the congestion of railroad lines at stations; third, the undue accumulation of provisions at any one point with corresponding deficiency elsewhere; and fourth, the possibility of large stocks being seized by the enemy. While the reason may not always be plainly apparent, it is a fact that the greater the distance from which supplies are ordered the less the likelihood that what is wanted will be actually received. By means of depots which are close enough so that their officers can be in actual touch with the needs of the troops at the front a far more satisfactory service is of course obtainable than where supplies are ordered through the War Department and shipment made direct from the manufacturer.

Light field railways are extensively used in advance of the main line railroads for the transportation, principally, of ammunition and engineering material. In the zone of the Fourth French Army about 500 kilometers of light railway are so used. The gauge is about 2 feet. All those railroads throughout the front of this army are connected by two main parallel lines, thus permitting access from one end of the line to the other. Machine shops and railroad yards are installed in connection with these roads. To prevent hostile observation, these roads are put on the reverse slopes of the hills, and the alignment is very poor as compared to a permanent road. Owing to the frequency of change of the rail-head there is very little accumulation of supplies there.

With these light narrow-gauge roads the rail-head can often be placed in the front-line trenches if sufficient cover is available. This 2-foot road can be supplemented in the trenches by 16-inch gauge with hand trucks.

Field railway commissions look after the construction, repair of the lines and buildings, installation of stations, the general upkeep of the system, and maintenance of proper order in and about the station and railway. They appoint station commissions and can establish regulation stations.

The motor car as applied to military uses has influenced practically every phase of campaign. As affecting tactics, it has permitted the rapid transport of troops over short and medium distances where rail transport, even if available, would have been slower than marching. Even with the best railroad facilities the motor truck is an invaluable adjunct provided good roads for its use are available. The railroad can reach only its station, but with a system of good highways the motor truck can load and deliver at practically any designated point and move through to its final destination without resort to marching at either end of the line. Moreover, this transport is not confined to short distances, as the European war has exhibited instances where troops have been transported over distances as great as 100 miles. The motor saved civilization at the battle of the Marne, for it was the rapid concentration of troops by motor car on the magnificent chaussées of France that turned back the tide of German invasion. The motor car likewise saved Verdun. For more than three months, during which time the Germans were incessantly attacking the fortress, an endless procession of motor trucks, two abreast in each direction, traveled the highway between Verdun and Paris.

Artillery is the decisive arm in modern warfare. Without adequate artillery support the best infantry cannot stand against the enemy. It has been well illustrated in the German campaigns against Russia, Servia, Roumania that the massing of artillery is as essential to its effectiveness as the massing of concentration of infantry. Mobility of the artillery requires that its transportation be motorized.

Heavy field artillery is utilizing motor transportation to an ever increasing extent, the heaviest types of guns and howitzers having been successfully transported. Guns of great calibre, weighing many tons, which formerly were used only in seacoast fortifications, are now employed on the field of battle. To develop their

full usefulness it is necessary that these guns be mobile and for the movement of such guns, well paved roads with moderate grades are absolutely essential.

For staff uses and the dissemination of information motor vehicles, including the motorcycle, are admirably adapted. Officers and messengers can cover a vastly greater territory than by the use of a horse, and with practically no fatigue. The result is that many officers of ripe experience and advanced age whose failing physical powers would formerly have prevented their riding horses, are now employed in the field.

The motor vehicle is extensively employed in the ambulance service, for which it is admirably adapted. In addition to its superiority from an humanitarian point of view, it has very great capacity for the evacuation of sick and wounded, thus contributing to the increase of the tactical efficiency of the army.

The miscellaneous uses of the motor truck include tenders for air craft, mounts for machine guns and lighter field pieces, especially for anti-aircraft work, dispatch and messenger service, etc.

The superiority of the motor truck over the horse-drawn vehicle is so evident as to need little demonstration. Under favorable conditions its speed is from five to eight times as great, fuel is less bulky and the life of a motor truck under war conditions is greater than that of an animal. Accordingly motor transportation permits an army to operate at a distance from its rail-head several times greater than would be possible with the use of wagons, or permits it to be supplied with a less number of vehicles.

The motor car in short aids in strategic and tactical concentration of troops and heavy guns and the defense of isolated points. It lessens fatigue and extends the theatre of command, inspection and reconnaisance. It greatly increases the scope of operation by increasing the mobility of the army and making it independent of local supplies. No army devoid of good motor transport can hope to maintain itself against an adversary well equipped in that respect. All armies will be equipped with motors, therefore their use will not permit a diminution of effort by belligerents. To impose one's will upon an adversary prepared for the conflict, the effort must in fact be greater than ever.

The greater the capacity of the motor truck the more economical it is as a carrier, provided the roads are suitable for its use. In many theatres where American forces will continue to operate for some time to come indifferent roads will be the rule and the economic

size of the motor truck is accordingly restricted to a capacity of 1½ to 2 tons.

The utility of heavy motor trucks appears to be overestimated, except where they are employed on the very best class of roads. Their use should usually be limited to the transport of articles whose bulk and weight prohibit the use of smaller cars. The question of road maintenance is a most serious one since, owing to its weight, the large truck is very destructive. Large trucks should be provided with a winding gear that will enable them to extricate themselves from the mire.

The French frequently use regular tractors on which they transport caterpillar tractors and thus bring them rapidly to the point where the heavy gun is to be taken off the road and across the fields. Here the caterpillar tractor is run off the regular tractor and used for transporting the guns.

Combined troop and freight carrying automobiles are also provided, the capacity being about 3½ tons of freight and 15 to 20 fully equipped infantrymen.

For movements of less than about 9 miles it is generally better to march and let the trucks carry the men's packs.

Motor transport demands good roads and even for animal transport they are to be desired. The construction of good paved highway takes time and accordingly military operations will be greatly hampered if they are conducted in a country which has not been provided in time of peace with a system of good roads. In the location and construction of a military road or railroad it is to be borne in mind that the question of time is paramount. The road will usually be constructed to meet the exigency of the situation and may later be altered and improved as developments require.

In the great countries of Europe the highway systems have been built with a view to their usefulness in war as well as in peace, but the United States is very poorly equipped in this respect.

Of course, when confronted with poor roads we can make use of caterpillar tractors, but such tractors operated on poor earth roads would be far less efficient than standard motor trucks on good brick or concrete roads.

The economic advantage of the auto truck over the horse-drawn vehicle is due almost entirely to the great average speed of transit of which it is capable under favorable conditions. On a narrow road with sharp curves, steep grades and poor surface, where the practicable speed of motor vehicles is little, if any, in excess of

that of horse-drawn vehicles, the advantages of the former mode of transport disappear. Were we to depend upon the wretched roads which now characterize most of the United States they would soon be reduced to mud or dust by the passage of heavy vehicles and this condition, combined with steep grades, would in most cases render motor transport impracticable or would so reduce its speed that it would offer no advantages over horse-drawn traffic.

Motor trucks will be utilized for highway traffic wherever they can move at the relatively high speed which is necessary if their economical advantages are to be realized. It is also to be remembered that military traffic usually moves in trains, or in a continuous stream, a fact which makes it somewhat easier to route and handle than desultory traffic. Ordinarily the loaded vehicles move in one direction and most of the empties in the opposite direction.

It is to be remarked that the advantages of very low grades cannot be fully realized unless a good surface is also provided, and conversely the advantages of a good surface cannot be fully realized unless the grades are held down. Accordingly it is of little use to strive for very low grades on a road which is not to be paved or to incur a great expense of time and money in providing a macadam pavement on bad grades. A good macadam road must have low grades. Low grades are far more useful to motor transport than to animal transport.

Highways should be laid out and constructed with a view to military use as well as the uses of peace, especially on those frontiers that are most apt to be the scene of military operations. A little intelligent forethought and supervision by the Federal authorities would meet military needs with a comparatively slight increase in expense. In France and other European countries this forethought has been exercised, and well has France been repaid for the money and thought expended on her roads, and great is the debt that civilization owes her. Our system of highways should be devised not solely for pleasure touring but with a view also to the efficient transportation of personnel and freight by motor truck.

Our splendid railroad system would be of vast importance in any war conducted on this continent. In case of an attack on our Pacific Coast we could rush munitions from the factories of Cleveland and Pittsburgh to the point of attack, but it would be of little use to have these supplies in California unless we were prepared, with good trucks and good roads, to distribute them to the points where they were needed.

It is of great importance also that there be no weak links in our system of transportation. Troops and supplies will move both perpendicular and parallel to the lines of battle and both cross and parallel roads should be paved. A section of unimproved road on an otherwise through paved route might become impassable for large trucks, necessitating breaking loads and transshipment, with fatal delays to traffic. A medium sized truck being more economical than a very small one, the system should be such that the larger truck having started from rail-head could go through to its ultimate destination, continuously on the same class of road. If transshipment from large to small trucks is necessary it should be dictated by causes other than the lack of continuity of good roads.

Separate roads for loaded vehicles to the front and empty vehicles returning are desirable, but one road with double track is usually more economical both in construction and maintenance. Horse-drawn vehicles, slow moving trucks and fast passenger automobiles should, when practicable, be given different routes, since the slow moving vehicles greatly delay the more rapid ones. Also the use of the same kind of road for automobile trucks and horse-drawn vehicles causes a rapid deterioration of the road. In the French system four lines of traffic of different speeds move one way on each of the broad chaussées, constructed for this very purpose.

A regular schedule for the movement of trucks and horse drawn vehicles somewhat analogous to railroad schedules will greatly increase the capacity of a highway for the transportation of freight. On the Bray-Maricourt road during the Battle of the Somme the French practically doubled the traffic by operating it on schedule.

The maintenance of roads under continuous military traffic is a very serious problem. The higher type of roads such as brick with concrete base, concrete and asphalt or tar macadam stand up much better and will carry heavier traffic, but when they do begin to go to pieces their repair is far more difficult because they require special materials, special plant and skilled workmen. Accordingly the usual type of road for military purposes will be the macadam or telford macadam with a wearing surface of gravel, broken stone or brick. Roads which are not originally of this class soon become so in war time. Railroad tracks are more easily constructed and more easily kept in repair, which is one of the reasons why rail transport should be utilized to the utmost.

In the repair of damaged roads the transportation of materials in vast quantities is one of the principal difficulties. Use must there-

fore be made of the materials which are at hand, amongst these materials the chief are demolished brick and stone buildings and walls, billets of wood, fascines and plank.

Numerous road signs sufficiently clear to prevent possibility of mistake should be prepared in advance and placed wherever they are required, at all crossings and at many intermediate points.

While it is in the theatre of actual operations that the military advantages of good roads are most evident, yet it is to be borne in mind that modern war is not a question of battle tactics alone. Every road in every part of the land which connects a producer of any commodity with a shipper or consumer of that commodity will play its part in enabling the nation to bring to bear its full strength in armed conflict, and the better the road the more effectively it plays its part. Good roads and railroads increase the useful productive capacity of our mines, fields and forests and are vitally necessary for the rapid concentration of troops and materials. Therefore, every good road which is a necessary artery of supply or travel as distinguished from a purely pleasure route is an essential part of the system of national defense even though it be not located in the theatre of actual military operations.

The influence of the officers charged with the supply of the army on the outcome of the campaign may be as great as or even greater than that of the officers commanding in the field. All wars are replete with examples of operations designed to cut the enemy's line of supply, which often is more disastrous and demoralizing to him than is tactical defeat in the field. The operations of Jackson and Early in the Shenandoah Valley in our own Civil War were designed primarily to cut the Baltimore and Ohio railroad, at that time the only through route between the east and west portions of the Federal territory. In his march through Georgia Sherman's advance was made along the line of the railroad, and the extraordinarily vigorous work of his railroad engineers in repairing the damage wrought by the Confederates in their retreat was the cause of Sherman's rapid advance which took the Confederacy by surprise, cut the south in two and brought the war to a conclusion. His advance supply depot was pushed ahead six times. These moves averaged twenty three miles and rail-head was at all times maintained within two marches of the troops. In Grant's '64 campaign against Lee similar activity was exhibited. He used the open sea as his line of communication, supplied himself from the flank and utilized five advance depots, to wit: Alexandria, Aquia Creek, Port Royal, West

Point, City Point, thus keeping his depot at all times within three marches of the troops and thoroughly protected, inasmuch as the Federal navy was in control of the sea.

The method of the present day is to lay plans in advance and to concentrate troops and artillery at the point of activity with such rapidity that the enemy cannot gather his forces to meet them even though he has knowledge of what is taking place, which he probably will have. The number of men to be moved and the weight of supplies to be transported is far greater than ever and they must be moved with greater rapidity, inasmuch as complete concealment is no longer practicable. This means plenty of roads and railroads, a network of transport line, all in good order, able to withstand the wear and tear to which they will inevitably be subjected, thoroughly equipped with ample rolling stock and especially with an active and intelligent personnel who are not bound up in red tape, but able to assume the initiative and to do things with that success which is the sole justification for any military operation.

The following is quoted from a compilation of the War Department, "there is an absence of red tape and a reduction to the minimum of the use of forms and documents in the movement of troops and material by rail."

The Supply Officer like the combatant officer must bear in mind that it is success alone which can justify his acts. If he fails to have the supplies on hand when they are needed he cannot justify or excuse his failure on the plea that he obeyed regulations and orders. Such a poor excuse will not condone failure in a critical case. Obedience to orders will not save him if he has failed to do his share. On the other hand, if he acts on his own initiative and disobeys his order failure will leave him in a still worse plight. Accordingly it will be seen that in no case can the issue be evaded. There is but one justification for a Supply Officer's acts, as for those of a Combatant Officer, and that is *success*. It would be well indeed if every Supply Officer would have these facts hammered into him.

You have heard the British saying: "If you don't know how, you get killed." This is perhaps peculiarly applicable to the transport service paraphrased something like this: "If *they* don't know how, we *all* get killed," and probably the most important matter for the supply officers to realize, is that in war time it is of the essence. When supplies are needed at a certain time and certain place any expense which is necessary to get them there is justifiable

because it would be small in comparison with the cost of the disaster which might result if the supplies were not forthcoming when needed. This is no violation of economic principles. It is merely an application of fundamental principles of economy to the conduct of war. It is necessary that the military man should have a just sense of proportion in this as in all other matters. The Quartermaster or Supply Officer who hesitates over the question of expending a few thousand dollars when the outcome of a battle and a question of millions is involved in his decision, or who permits himself to entertain doubts as to whether the regulations will permit him to furnish supplies which he knows are urgently needed, is not the sort of man we wish to have at our back when we are on the firing line battling for the life of the nation.

ORGANIZATION AND DUTIES FOR TRENCH FIGHTING

by

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CHAPTER IV. THE RELIEF.

I. DEFINITIONS AND PRINCIPLES.

There are two kinds of reliefs, General and Interior reliefs.

A *General Relief* is one where a large unit, such as a division or an army corps, is relieved from its position on the front.

An *Interior Relief* is one where a small unit, such as a company, battalion or regiment, is relieved from its area by another unit of the same division within the position.

A general relief takes place for the following reasons:

In order to send a unit far to the rear to good billets for complete rest and perhaps for recruiting;

To withdraw and gather together the units of a corps, for the purpose of training for an offensive;

To permit the strategical movement of large units along the entire front.

General reliefs should not be made any oftener than necessary as they hinder methodical and continuous organization of the defense, observation of the enemy, and the preparation of contemplated offensives. It is for the express purpose of decreasing the number of general reliefs that troops are disposed in depth in a position so that continuous defense of the sector will be assured by means of successive interior reliefs. As an example of interior reliefs, we will consider a division holding a part of the front with two regiments disposed in the first position, one regiment near the second position in billets, and the fourth still farther to the rear in complete rest. These regiments, by a system of interior reliefs, will rotate to equalize the tours of duty in the first position. Similarly

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the battalions of the regiment in the first position will rotate to give equal divisions of time to each in the first lines. Assuming that a period of six to eight days spent in the front line is a fair average and considering the fact that troops are disposed of in depth throughout the three lines, different combinations of reliefs are possible. The work of making out the schedule of reliefs falls upon a division of the general headquarters.

The sector period is variable with the activity of the enemy and conditions of life in the trenches. During the German offensive at Verdun the sector period was four days, while in Lorraine, during that time, the same size unit could remain in the trenches for three months without necessity of relief.

II. PRELIMINARY DISPOSITIONS FOR THE RELIEF.

Time to Prepare the Relief. Usually the order for the relief is issued from the general headquarters to the regiment 48 hours previous to its execution. Sometimes, however, for tactical reasons, such time cannot be allowed, and the regiment may have to go immediately into the trenches. In such case, the different operations of the relief, which are taken up in this chapter, are shortened, but must not be carelessly executed. In the present condition of trench warfare the proper execution of a relief is of the greatest importance.

Preparation. A relief is executed at night. Thirty-six hours before the relief is made the men of the relieving units proceed to clean, and get in shape, their arms, equipment and clothing. When the relief is not for a special offensive operation, the troops go into the trenches with full equipment. All non-regulation articles are left behind with the regimental train, in care of the non-commissioned officer left with it. Also, the files, books, and official papers of the unit are left here. The regimental train establishes itself in rear of the sector of its regiment.

Besides this material preparation, the officers of the relieving companies are responsible for the morale of their troops. Before going into the trenches there may be some apprehension on the part of the troops, which must be dispelled by the officers. The great factor of depression is the mystery of what is not known of the sector about to be entered. Platoon leaders and company officers try to clear up this difficulty by telling their men what is known of the sector they are going to hold, and otherwise speaking words of encouragement.

Reconnaissance. Prior to taking over a sector, a preliminary reconnaissance is made by a certain number of officers and orderlies. They are:

For the Regiment. The colonel and part of his headquarters staff (adjutant, intelligence officer, telephone officer, engineer officer, medical officer, supply officer).

For the Battalion. The Battalion Commander and his adjutant.

For the Companies. The company commander and one officer for each company. Machine gun company commander and one machine gun officer.

The commander of the 37 mm. gun platoon.

Messengers and telephone men at the discretion of the adjutant and the company commanders.

The above reconnaissance parties will go into the trenches on the morning of the day preceding the night relief. They must start early enough to permit a certain number of officers of these parties to return to the billets with all details and information necessary for the movement of the relief into the sector. The adjutant and the lieutenants of each company remain in the trenches until the relief arrives. During the intervening time they must acquaint themselves with all details of the sector, necessary for the execution of its defense.

This preliminary reconnaissance affords an opportunity to the different leaders and chiefs of service to note the particular things of interest to each:

For the Colonel or Battalion Commander. The general organization and defense of their areas.

For the Adjutants. The works under construction, precautions against gas attacks, etc.

For Officers of the Regiment Headquarter Co. Information as follows:

Information Service. Activity of the enemy, microphones, observation posts and observatories, carrier pigeon posts, signal rockets.

Telegraph Service. Telephone systems, flashlight posts, wireless or ground telegraphy installations.

Engineer and Ordnance Service. Depots and Supply (material and ammunition) special engineer works, trench mortar emplacements.

Medical Service. Dressing stations, evacuation of the wounded, hygiene, latrines, etc.

Supply Officer. Emplacements of the kitchens, food supply.

For the Company Commander. Location of the platoons (number

of men holding the first line and distribution of same. Platoons in the cover trench and support line). Shelter accomodations, alarm signals, artillery support (limits of barrage fronts and barrage calls.) Counterattacks (troops and directions for counterattacks). Information of the enemy (observation posts of the support point). Supply (engineer dumps, kitchens, ration supply parties, water).

For the Machine Gun Company Commander. Distribution of machine guns and emplacements, limits of machine gun fire sectors, emergency and special uses of M. G.

When such a complete reconnaissance cannot be made, only commanders of units precede their troops and make a short reconnaissance of one or two hours.

REGIMENTAL ORDERS.

Relief Orders—

(1) Usually the general order for the relief of a sector is settled on in conference by the colonels of the relieving and relieved regiments. This order is sent to the battalion commanders, if possible, before the reconnaissance.

The order of relief contains the following paragraph:

Day and hour of the relief, designating the relieving and relieved units.

The name, limits and division of the sector with designation of the neighboring units.

Information of the artillery support, its composition and emplacements.

Orders for the reconnaissance, its composition, and the hour when it must be finished.

Orders for the movement of the relief; march of the regiment from the initial point to the point of dispersion where the battalions branch off to their particular areas. If the regiment is transported in motor trucks, points and orders for entraining and detraining. Hours of departure of each battalion from the dispersion point and special itineraries for each.

Movement of the relieved troops. Assembly points of these battalions.

Movement of the regimental trains, relief of the kitchens, supply measures for furnishing of provisions, orders for the sanitary personnel.

Hour at which the new colonel takes command of the sector.

Battalion Orders—

(2) All details for the relief are fixed in the battalion relief order issued by the battalion commander. This order is sent out immediately upon his return from the preliminary reconnaissance and in accordance with the regimental order.

The battalion relief order contains the following points:

Hour of leaving the dispersion point.

Order of march of the units (the companies march in the order in which they are to relieve the units in the sector, from right to left in the first line, and similarly in the support line).

Itinerary to the entrance of the trenches.

Meeting of the guides, hour and point of rendezvous, play of the guides of the relieved battalions.

Movement of headquarters, and rendezvous of the messenger that each company sends to headquarters to establish liaison.

Order of supply.

Additional details (result of the reconnaissance).

Departure. Before departure, each company is inspected by its company commander who must see that each man has his canteen full, his rations for the day, a full supply of cartridges, the magazine of his rifle loaded (no cartridges in the chamber) and his gas mask in good condition. In winter the relieving troops will find a supply of blankets and trench boots in the sector. Usually each man should carry an extra supply of cartridges above that laid down by regulation, and two sandbags. There should be a certain number of flashlights and candles to the company (each corporal carrying a minimum of two candles). Just previous to departure or entraining the battalion commander himself makes a general inspection of his unit.

III. MOVEMENT OF THE RELIEF.

March to the Rendezvous Point of the Guides. Usually the regiment marches, but it is sometimes transported in motor trucks, up to a point in the rear of the sector, called the point of dispersion, from which the different battalions branch off successively to go to their respective areas. This practice avoids the crossing of units. A short meal may be had by the regiment at the point of dispersion. The distance of this point behind the sector and the time of arrival of the relieving unit must be carefully calculated so that the relief may be finished early enough to permit the unit relieved to get out of sight of the enemy before daylight.

When the battalions leave the rendezvous point, each company sends to the battalion headquarters two messengers for the purpose of liaison. The units now follow the prescribed itineraries up to the rendezvous point where the guides are met.

Guides. During the reconnaissance, the company to be relieved details certain men to act as guides for the incoming company. An

average of two guides are furnished for each platoon, one for each company headquarters, and one for each battalion headquarters. These guides await the arrival of the different units at a certain point called the rendezvous point of the guides. Usually this point is at the entrance of the boyaux. As several guides are usually grouped at the same rendezvous point, they must be alert to meet the unit to which they are assigned. A non-commissioned officer of the retiring battalion is in charge of this group and he is responsible that each guide finds his unit. Each guide, of course, must know the best and safest route by which to conduct the unit to the position they must occupy.

March in the Boyaux. From the rendezvous point, the companies continue their march in the boyaux which are assigned to them. One guide leads each platoon while the second guide brings up its rear. The leading guide must inform the platoon commander of the different points of interest that are passed, such as each line of the sector, regimental or battalion command posts, depots, water points, etc.

The march in the narrow boyaux of an unknown sector, in the darkness, and with full equipment, is difficult and depressing. Consequently, the rate of march must be slow. When the head of the column meets an obstacle, a warning word is passed in the rear along the single file. (This rule is above all useful to prevent accident to telephone wires.)

The march must be executed without noise. Orders are given in low tones. Smoking or the use of flashlights is prohibited. No disciplinary measure is too severe that will prevent the enemy from discovering the relief. It is absolutely prohibited to talk over the telephone concerning a relief otherwise than a cipher.

IV. OCCUPATION OF THE POSITION.

Details of the Relief. If the two units have the same number of men, the relieving of one unit by another is simple enough. But often the relief is complicated by the fact that either the extent of front or the number of effectives is different. In such a case, the officers of the two units must settle, during the reconnaisance, upon the necessary modifications for an effective and expeditious relief.

When the company arrives at the command post of the captain, the platoons are relieved from right to left in the first line, then in the cover trench in the same order. If there is a platoon in the support line this is next relieved.

In the first line, the relief of the platoons is executed in two parts. First of all, the sentinels, observers, watchers, men in the listening posts, and the N. C. O. of the watch, are relieved. When this is done, the remaining men of the platoon are relieved. The men of the old platoon occupy their places at "Stand To." The relieving platoon files in and steps up on the firing step. At the command "Pass" which is given quietly, the old and new platoons change places.

Each retiring leader, of whatever command he may be, hands over his orders and information to the corresponding leader who relieves him. For example, one platoon leader will turn over to the other all information concerning guard duty, defense of the line, condition of the barbed wire entanglements, patrolling, and shelter accommodations. This must be executed rapidly but with precision.

The platoon relieved assemble at the entrance to the boyaux, and leaves the trenches under the chief of platoon. This is not done, however, until the platoon leader has reported to his captain, by means of his guides, the execution of the relief. The old captain fixes a point for the assembling of his platoons, but this point must be far enough to the rear to avoid blocking of the boyaux and out of reach of hostile grenade and trench mortar fire.

In the meantime, at the command post of the Support Point, the new captain acquaints himself with all information and orders pertaining to the support point from the old captain. When this is finished he telephones the command post of the Center of Resistance the completion of the relief, and asks if his predecessor may retire. The relieved company then takes up the march, following the prescribed route up to the assembly point of the battalion.

It may be stated here that the relieved units must leave their trenches in as clean and sanitary a condition as possible. The work of clearing up the shelters and latrines must be thoroughly done before the arrival of the new units. Depots must be left in good condition and contain the amount of supplies called for by regulations. The platoon commander is responsible that his men do not forget tools and cooking utensils in the trenches.

Duties after the Relief. In each support point, the new captain immediately establishes liaison with the command posts of the neighboring units to right and left. Communication between the captain and his battalion commander is obtained by means of the

two messengers detailed to the battalion for that purpose and who now return to their company.

When the battalion commander has received the information from all his captains that the relief of his area is finished, he reports the same by telephone to his colonel. A confirmation of this report will be made the next morning in his daily written report which will cover the following points:

The general condition of the relief.
Hour of completion of the relief.
Casualties during the relief.
Living conditions in the trenches.
Requests for tactical modifications (new dispositions of the garrison).

The relief finished, the battalion commander must also establish his liaison latterly and to the front and rear, but especially with his artillery support, by means of the artillery N. C. O. detailed to his area for that purpose.

Finally, the battalion commander investigates and perfects the organization of the food supply.

In the sector headquarters, the new sector commander will find on file all records, reports, orders, and detailed information concerning all the elements of defense of the sector. The sector file will contain the following documents:

Plan of organization.
Plan of defense.

Files of information concerning:

Machine guns.
Trench Mortars.
Artillery support (table of barrages and other fires).
Liaison (telephones, runners, signalling, etc.).
Supply and evacuation.
Measures to combat gas attacks.

Besides these are the files of the different reports:

Sector daily reports (kept by the adjutant).
Intelligence reports (kept by the intelligence officer).
Construction reports (kept by the engineer officer).
Maps, sketches, and aeroplane photographs (kept by intelligence officer).
Inventory of the sector depot (kept by engineer officer).

Any officer of the sector, as for example a machine gun officer, has access to these files to more thoroughly acquaint himself for the execution of his duties.

MINING OPERATIONS, ESPECIALLY FOR INFANTRY

Mainly translated from a lecture to cadets at Saint-Maixent, France

By

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The object of sapping and mining works is to give to an assailing force the means of approaching to a fortified position to make an assault. They are then of an essentially offensive character. They are employed when, after having occupied successive portions of approach the enemy's fire makes it impossible to take a new position by main force, and when the distance is too great to make the assault. We must then have recourse to artificial approaches, which are called saps if in the open air and mines if they are under ground. The latter affords a means of destroying the enemy's works by explosives.

Mine warfare dates back to high antiquity. From the beginning of the Roman epoch, in about 430 before the Christian era according to Titus Livins, Servilins, besieging the Etruscans in Fidenæ, found nothing better than to dig a subterranean gallery through which his soldiers debouched in the heart of the city, which they then captured. This is the first historic example of an *offensive* mine.

The *defensive* mine also dates from a remote epoch. Under Philip II, of Macedonia, in the fourth century of our era, the countermine was known. If the besieger drove mines or subterranean galleries against the city, the besieged knew how to make a countermine: a deep ditch in front of the ramparts, where they accumulated dry wood.

When the besieger's mines arrived at this ditch, they set fire to the wood, which they covered with sods, so that the smoke was driven into the enemy's galleries and asphyxiated the occupants. Certain captains let loose swarms of bees; they also say, even bears and wild beasts,—at Themiscyrus, for example (58 B. C.),—or many things both unclean and disagreeable. At Appolonia, the

besieged detected the bearing of the enemy's mines and dug shafts communicating with them, shafts through which they poured water and boiling pitch, night soil, and red-hot sand.

The school of the sapper should be known to the infantryman, as well as to the engineer sapper. The infantryman also should know how to attack and to construct a mine gallery, a shaft, and a branch; to make a boring, and demolitions in the simplest and quickest manner. The infantry lieutenant, the pioneer officer of the battalion, will often have to employ technical rules and the simplest formulas of Sapping and Mining.

The regulations say:

> In such matters it is well to teach the officers and non-commissioned officers to give the technical terms their true value. The special arms observe the nomenclature and appreciate it. The infantry is less scrupulous, and regards as narrow minded those who show that they are careful about terminology. If, however, such expressions as "ordinary sap," "deep sap," "Russian sap," "covered sap," always implied, as they should, not only precise objects but also their methods of construction and their normal dimensions, all would understand each other better; that is what happens in the Engineers where the bare statement of the work to be done is in itself sufficient without other explanation—as if one should command "company column," or "line of sections by fours."

In advancing against a fortified position, when the enemy's fire of artillery, musketry, or grenades is so effective that other means of attack are impracticable, the engineers sometimes dig subterranean galleries leading to mine chambers, generally placed under the salients, or under especially well guarded points of the enemy's line, houses organized for defence, machine-gun shelters, flanking positions or observatories. The chambers are prepared to receive a quantity of explosive which varies with their depth below the surface of the ground. The explosion of the mine chamber is the signal for attack. The craters formed by their explosion are immediately organized against any encroachment of the enemy.

The mine chamber is reached by subterranean or interior communications, which are called shafts when they are vertical and galleries when they are horizontal or not too steep for one to walk upon their lower surface. Small galleries are called branches. Finally the small long holes, which are sometimes made to place mine chambers rapidly at the proper points, are called borings . . . There is a special method of construction for the shafts, the galleries, the branches and the borings.

The miner should know what he has to do, how to do it, and

about how much time it will require. The chief of the section of infantry must have a general knowledge of the work and so must the pioneer officer of a battalion who must excavate shafts for drainage, galleries for cave shelters, branches to reach these shelters, depots of material and of arms, tools, and munitions; borings to reach the lower beds of impermeable ground, etc., etc.

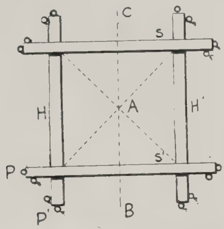

Fig. 1. Construction of a shaft, "laying the top frame."

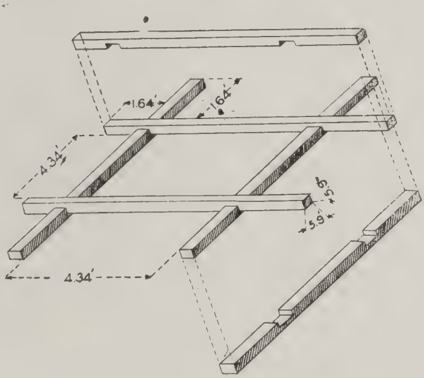

Fig. 2. Assembling the top frame.

Construction of a Shaft.

With a picket *A*, mark the center of the shaft. With two pickets, *B* and *C*, mark the direction to which the faces of the shaft should be parallel or normal (Fig. 1).

Then (Fig.3) make a frame with overlaps 1.32m. in the clear, for the top frame, the sills *HH* mortised, and the caps *SS* lodged exactly in the mortises. (Fig. 1 and 2.)

Placing of the Top Frame. Assemble the frame, lay and level it, and secure the whole system; arrange the ground around

it to shed the waters from the entrance of the shaft (Fig. 3) . . .

Support of the Walls. In good ground the walls are supported by a sheeting of planks, in bad ground by sheeting frames . . . Infantry should know how to place a top frame. That which relates to the crib work will call for engineer specialists.

Personnel and matériel. One sergeant or one corporal supervising two miners, and one or two assistants.

Three shovels, of which 1 has a short handle; 2 picks, of which 1 has a short handle; 1 push pick, 1 hand-ax, 1 pincers, 2 sledge-hammers, 1 box of tools with a hammer, pincers, gimlets, and boring bits, 2 saws, 1 of which is a keyhole saw; 1 mason's level, 1 meter rule, 1 square, 1 plumb-line, 1 cord, 1 winch, 1 miner's basket and 1 barrow.

II. CONSTRUCTION OF A GALLERY.

The entrances to a gallery or the exit from a gallery can be made: *1st,* on a slope; *2nd,* in a wall; *3rd,* at the bottom of a shaft.

Personnel and Matériel. A sergeant or corporal superintending, 2 miners and assistants in proportion to the progress of the gallery (1 or 2 at first).

The same tools as for the construction of the shaft, plus a scraper, a sweep, cleats, and lighting apparatus, but minus the windlass and its accessories.

Entrance to the Gallery. The problem for the pioneers of infantry is the most simple; it will generally be to open the gallery perpendicularly to the front wall of the trench on one of the walls of a *boyau,* or on the walls of a shaft.

Construction of an Interval. This comprises: *1st* digging; *2nd,* laying of the frame work; *3rd,* sheeting. The intervals are about 1 meter. (Fig. 4.)

Sheeting. Fig 5 shows clearly the manner in which the planks are placed on the caps of the sheeting. The planks of the lateral sheeting are laid according to the same principles, commencing at the bottom.

Additional Details. 1. In bad ground the work is more complicated. It is necessary: *1st,* to give a firm point of support to the ceiling planks which are pushed in as the digging advances; *2nd,* to keep the gallery from caving in. We place: *1st,* the false frame, in front of the last frame laid. This gives a second point of support to the ceiling (see Fig. 7); *2nd,* the mask, made by planks equal in length to the breadth of the gallery. These planks are laid against the bottom of the gallery, and pressed against the uprights by means of battens. We place these plank masks successively from top to bottom.

2. Completely fill up all the voids.

3. If the slope is greater than 10 centimeters to an interval, surmount the caps with triangular furring.

4. For the greater gallery and the great gallery and afterwards for the construction of a large cave shelter it is necessary to use the method of double

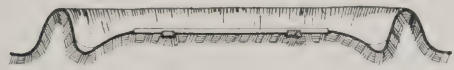

Fig. 3. Construction of the platform.

Fig. 4. Construction of a gallery interval with frame and sheeting.

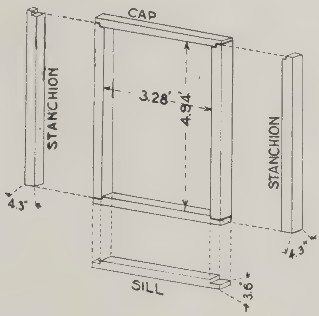

Fig. 5. Frames.

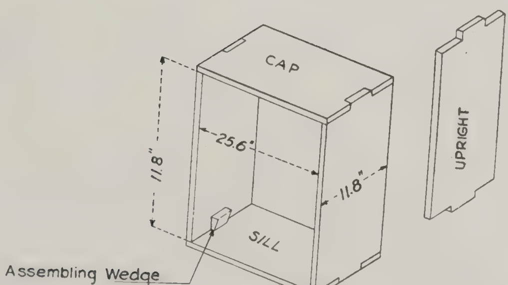

Fig. 6. Cases.

attack by making the digging in two successive stages, each of half the height. This will double the rapidity of the work.

Personnel. 1 sergeant, 8 sapper-miners in two squads of 4, helpers of indefinite number. Tools for each squad as for the construction of the gallery by the ordinary process. In the double attack this personnel is doubled.

CONSTRUCTION OF A BRANCH WITH SHEETED FRAME.

Personnel and Matériel. The same personnel and the same matériel as for the construction of a gallery by the ordinary process.

Entrance to a Branch. Operations similar to those indicated for the entry into the gallery (see section 2, Nos. 1 to 6).

Construction of an Interval. Make the digging of dimensions strictly sufficient to lodge the joined frames (Fig. 6), and assemble them in the following order: *1st,* the ground sill; the stanchion with two tenons; the top sill; the stanchion with one tenon; the assembling wedge.

In bad ground, place a false-frame, reaching from the level of 2 or 3 cm. to the top of the gallery. Set up this false-frame on the next to last sill already laid (Fig. 7).

Between the cap of the false-frame and the top sill frames already placed, engage sheeting planks, *P,* all together equal in width to the trench. Drive in the planks in front, and if necessary make the groove, *R.* Under the protection of these planks, prepare the place for 1, 2 or 3 frames, *C, C.*

In that way the level is successively lowered. When we again meet ground sufficiently consistent, resume the ordinary rate in regaining the proper elevation.

CONSTRUCTION OF A GALLERY OR OF A BRANCH BY A RUSSIAN SAP.

In rock or in very difficult ground (hard limestone, sandstone, tufa, chalk, etc.), wooden casing in the galleries and branches is not indispensable. In this ground, and even in ground of less resistance, it is safe to advance by giving to the approach the form of the Russian sap.

In rocky ground one generally advances by small blasts. These converging holes are made by a jumper and each hole is loaded with one or two cartridges of cheddite of 135 grammes. The rupturing effects are very good.

Personnel and Matériel. As for the construction of the galleries.

Construction of Borings. Narrow and long passages (ascending or horizontal) by which in certain cases mines may be rapidly placed at the proper point.

There are drilling apparatus of small diameter (5 to 6 cm.) or of large diameter (9 to 25 cm.); among the former the most useful

is the jumper, an iron rod, carrying at its extremity a special tool and acting by percussion or by rotation.

After having made the boring, we proceed to the chambering; that is to say, that by the aid of a feeble charge of explosive we create at the end of the boring a chamber capable of receiving the charge. When the charging and priming are completed we tamp by stopping the hole with earth, etc. When the ground is suitable, the

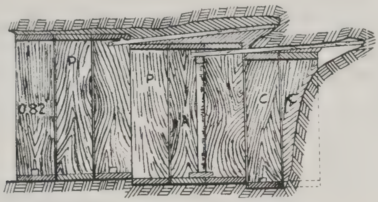

Fig. 7. Construction of an interval of a branch in bad ground.

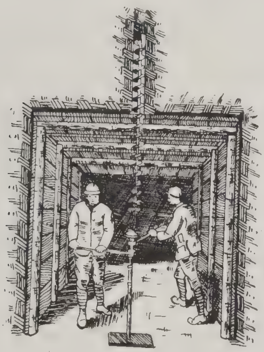

Fig. 8. Guillat-Genie Auger.

diameter of the boring may be increased so much that after a little sheeting a man can enter without danger. A boring thus enlarged and sheeted is called a "bored branch" or, if it is vertical, a "bored shaft."

Special Apparatus for Mine Works.

The considerable extension given to mine works has stimulated the invention, at least the application to military work, of certain types of perforating apparatus employed in civil engineering.

The Guillat-Genie Perforator. Fig. 8 makes it possible to bore rapidly by hand vertical holes or holes inclined by as much as about

45° from the vertical, 10 to 12 meters in length and 150 millimeters in diameter. It is employed in shelters, cavern shelters, mine galleries for ventilation, passage of periscopes, etc. Infantry should know how to handle it, because apparatus for rescue are placed in the most exposed shelters of the front for use in case of artillery preparations or bombardments of the enemy. In case the shelter is obstructed, the men imprisoned can make holes to call for assistance, to admit the air and to receive food, medicines etc., until they can be delivered.

Tubular Mines. Steel tubes, generally ordinary gas pipes can, in certain soils, be driven in by pressure alone. The diameter of these pipes reaches 100 mm. in the forward part and then gradually decreases so as to reduce the friction. The great length of thrust which has been realized with pipes joined

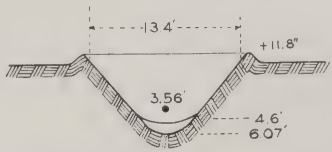

Fig. 9. Bored sap.

together by sleeves is 84 meters; the average speed is 15 meters. They are employed in compressible and homogeneous soils. In practice, in clay. Infantry may use them for—

Bored Saps. Tubular mines driven parallel to the surface of the ground at a depth of 1.10 meters and loaded for all its length with about 2.700 k. of cheddite to a running meter gives in exploding the embankment of a sap which has only to be dressed off to make it complete (Fig. 9). Do not start this sap at the branch itself, but leave a thick merlon of earth in front of it and communicate with the sap by a crotchet made during the excavation.

Branches and Chambering. The explosion of a tubular mine gives a chamberage whose diameter varies from 1 m. to 2.50 m., according to the charge per current meter.

These chambers can be utilized at once for galleries or branches, but ultimately have to be sheeted to guard against crumbling caused by leakage. (Fig. 10.)

The material of the tubular mines can be adapted to other uses,

such as to inject asphyxiating gas, to convey air and food to miners cut off by an explosion, etc.

The works of sapping and mining should always be in *liaison* with the exploration above and below the ground.

The exploration above ground comprises observations by air craft and balloon surveys, observation, and from our own lines, patrols, etc.

Observation by air craft serves in connection with surveys of our own and the enemy's positions to keep tally of the progress of the sap heads, which may serve as an entrance to a gallery, and of all trenches or pieces of sheltered ground between the two positions. The surveys made by air craft are completed by plotting the data

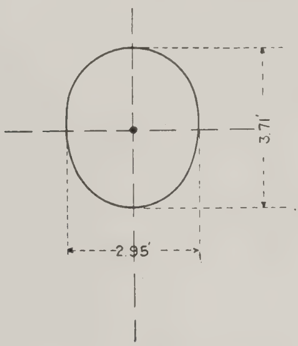

Fig. 10. Bored branch.

we have about our own position, especially about the saps and the probable changes in their heads. We try to ascertain whether earth has been thrown up on the enemy's land, as this can come only from subterranean works. Among other indications of a hostile attack are a pile of sand bags, the appearance of large banks of earth, reinforcement of accessory defenses in front of suspected galleries. From a balloon or an elevated observatory we can see whether hollows or sunken roads in rear of the enemy's first line have been filled with earth, and whether there are organized trenches or craters there which can be filled with excavations. We should not neglect the evidence of machines at work (appearance of exhaust steam, sounds periodically repeated, etc.). Special attention should be given to points of tactical importance, and those from which an attack may start; such as, salient angles, ground along highways, and isolated farms in the first line.

Reconnaissances made by patrols are of great importance. The exploration under ground will be made by the regularly organized Listening-in Service.

MINE WARFARE.

I. *General Ideas.* In those sectors in which troops have been *halted,* which have, from time to time, been prepared for defense, and where it has become difficult to advance on the surface, subterranean warfare begins. Here the sappers play the leading rôle, and hold it with remarkable audacity. Mine warfare is full of stratagems, in which specialists have to combine their science with their indomitable spirit and decision. Parties operating in the bowels of the earth oblige the rival squads to engage in hostile combats, which, throughout a wide region, are terminated by explosions more and more terrible and annihilating.

Subterranean galleries are started from the mine lodgment (Fig. 11), a sort of a parallel connected with the ground to the rear by communications well defiled or covered. Magazines for explosives are built when required, as well as firing posts, telegraph posts, etc. If the chambers are not to be placed more than 40 meters from the mine, they debouch in branches. For a greater distance, a gallery is made. The debouches are from 15 to 20 meters apart (Fig. 12), they are sheltered by a blinded cover or by a small portion of a blinded sap. Shafts are employed only when necessary to reach a rock bed more easily (Fig. 13). The ventilation of the galleries is secured by ventilators. For illumination during the day, mirrors reflecting a solar light are employed; at night, reflecting lamps. Electric lighting is installed wherever possible.

II. *Subterranean Struggle.* When the attack has discovered the existence of a system of countermines, it tries to form craters or lines of craters at the surface of the ground, to use for new debouches. At the same time they try to destroy by explosions the communications and mines of the enemy. For this purpose ordinary mines or mines slightly over-charged are placed as deep as possible below the surface of the ground. When the mines are charged with *melinite* care must be taken with the very poisonous gas caused by the explosion, which is very injurious; ventilate the infected galleries energetically before entering them. *Melinite* can be used by similar means to annoy the enemy. The mine chamber is made by a shaft about 0.60 meter in depth, placed at the head of the branch or by the end of the branch itself. Black powder is, as far as pos-

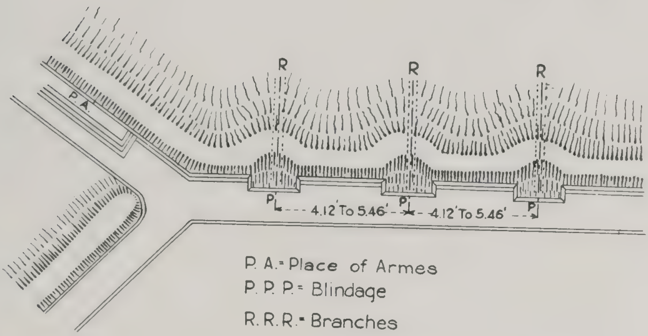

Fig. 11. Lodgment.

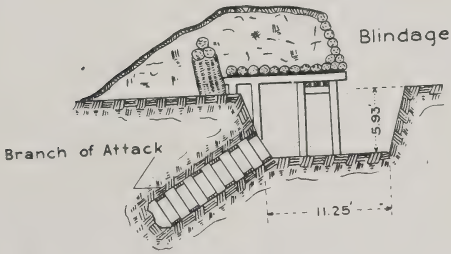

Fig. 12. Direct debouch in branch of mine lodgment.

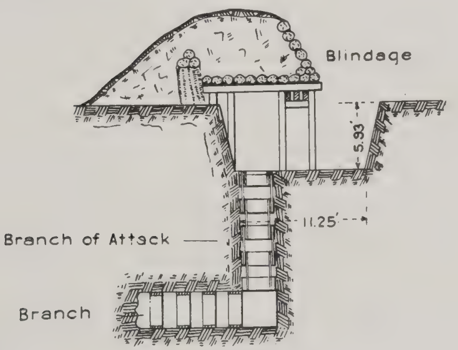

Fig. 13. Debouch in branch at the bottom of a shaft made in the mine lodgment.

sible, used in the cases, boxes or barrels (of wood, copper or zinc) in which it is preserved. Then a wooden mask is placed against the chamber and the boyau of approach is tamped and filled with rammed earth, sand-bags, sods, etc. (Fig. 15.)

With high explosives (*cheddite, melinite*) the tamping is simplified. The tamping serves not only to assure the maximum explosive effect around the crater itself, but it prevents the gallery from being invaded by the asphyxiating gases which result from the explosion. Before firing the mine, the troops are made to retire from the trenches out of range of the zone of projection excepting:

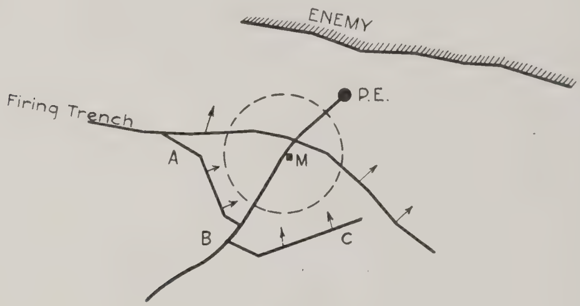

Fig. 14.

1st. A detachment charged with the firing. *2nd.* A detachment of miners who keep under the most advanced shelters to observe the effects of the explosion as soon as it has taken place. *3rd.* A detachment of infantry (*fusiliers, grenadiers, pionniers, mitrailleurs*) charged with the occupation and (in connection with the sappers) with the organization of the crater.

Whenever we suspect the presence of a mine chamber (sounds continuing for lapse of time and having suddenly ceased) we should then decide to explode a crater before the enemy can do so. If, according to the engineer officers, the mine seems to be under the point *M* (Fig. 14), and if the mean diameter of the craters in this region is from 30 m. to 40 m. we make two trenches, *AB* and *BC*, 2 meters outside of the probable circumference of the crater. We vacate the part of the trench exposed, and prepare to jump from *AB* and *BC* across the line of danger.

III. *Operations of the Assailant: Mines, Craters.* If the explosion has taken place at night, gabions, rapidly filled, are placed on the edge of the crater toward the enemy. If the explosion has

taken place by day, and if it is too dangerous to have a large number of men enter the crater because of bombs and grenades thrown by the defense, a provisional crowning is made by raising the edges of the crater by means of sand bags. When night comes, the gabions are put in place (Fig. 16). In every case a reservation for the

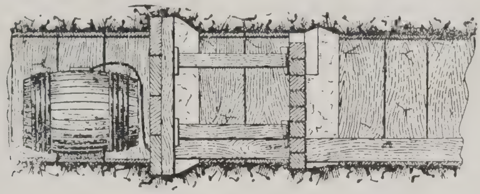

Fig. 15. Closure of a chamber in prolongation of a branch.

gabion emplacements should be allowed for along the crater, their upper part remaining about the height of the lips. The gabions will thus be less visible and better protected. In front of the organized lip, *chevaux-de-frises* and accessory defenses of all kinds are

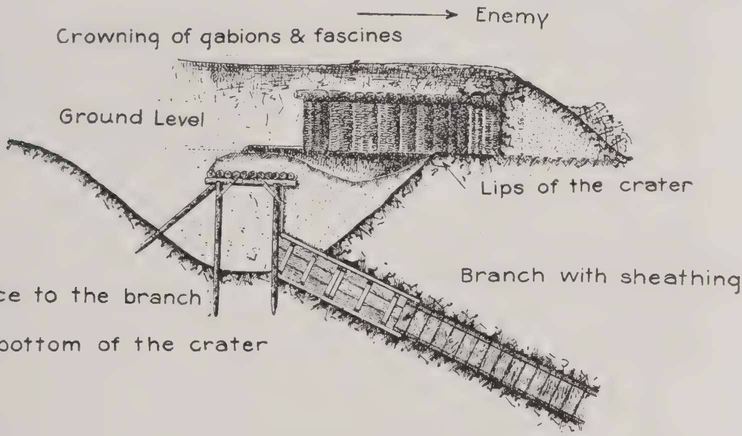

Fig. 16.

accumulated. The crater is then connected with the trench of departure by deep covered saps or by galleries. Then these craters are united together (making a line of craters). Finally, at the bottom of the craters, we debouch into a branch so as to continue the subterranean struggle by preparing beforehand a new line of craters. When the enemy has not established a system of countermines, the assailant tries to reach the ground beneath the work without being discovered; he avoids sounds, and movements in the

subterranean passages and makes explosions only when the activities of the defender require it. The operations will be rapidly conducted to end in the destruction of the enemy's work. (Fig. 17.)

IV. *Operations of the Defense: Counter-mines, Listening-in Service, Camouflets.* The defenders try only to destroy, by camouflets, the communications and the mine chambers of the attack. They establish, with advantage, a system of counter-mines (Fig. 17) designed to resist the enemy's subterranean progress. A system of counter-mines is composed essentially of main galleries or listening galleries, *EE* (Fig. 18) 30 or 40 meters apart, spreading out like antennæ from the counterscarp of a gallery *AB* behind them. The listening galleries have each a distinct entrance as much for the security of the communications as for ventilation, but they can

Fig. 17. Section along the axis of the demi-galery if attack, and the branch of the enemy's countermine. The French miner has destroyed the German branch by a camouflet and having arrived within good range beneath the German trench he installs his mine.

be united by transversals like *TT*. Emplacements to debouch on the branches or to install dumps for boring are placed along the listening galleries, and even in the transversals. The branches are usually excavated at the moment of need, but some should be driven far enough to make it possible to hear the enemy's miners before beginning the subterranean struggle and operate more surely against them. In the exterior the gallery, *AB,* is connected with the fortification in the rear by communications either in the open air or underground. In the latter case, we prepare in advance demolition mines so that the enemy can not use these communications to place his breaching mines. The rôle of the listeners is especially import-

ant. At the hours fixed by the officer on duty, the sergeants in charge of the listening-in have the work suspended at once in all the branches under their control, and make everyone listen in the greatest silence for a few minutes. In order to listen, the observer can place his ear against the stanchion or the ground sill of the gallery frame; or place bells or peas upon the well-stretched drum-head, or better still, take a small vase containing mercury, the surface of which wrinkles with the slightest vibration. The most efficient means of detecting the presence of the enemy's miner is by a microphone. The sensibility of all these apparatus is increased by placing them on a plate of sheet iron 1 cm. in thickness applied to the floor of the gallery.

The sergeant, chief of the listening-in squad, checks the informa-

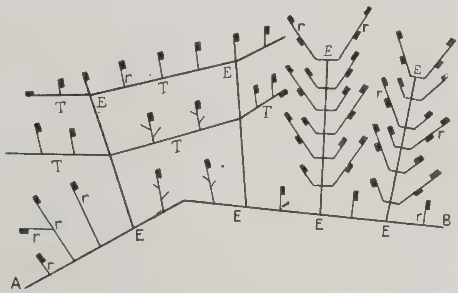

Fig. 18. Disposition of countermines (scheme).

tion of the listeners, notes it, and makes his report to the officer in charge as soon as the work is resumed. In case the mine of the attack explodes an effort should be made to prevent, by infantry fire, the occupation of the crater, or to render it untenable by grenades, bombs, torpedoes, etc. Suppose on the other hand that the presence of the enemy is signaled by the listening-in service. Their counter-sap must be destroyed. Cautiously—the direction having been accurately observed—our sappers force, with a jumper, the wall which separates them from the approaching gallery. (Fig. 19.) When they have nearly pierced the wall they replace the jumper by a tube by means of which they slide a certain quantity of explosive close to the enemy's gallery; nothing more remains but to ignite it. If the operation has been well planned, and if the charge of explosive has been well calculated, there is no exterior effect, no sheaf of earth, no crater. The effects are all subterranean; this is a camouflet. The counter-mine in exploding crushes the gallery of

Fig. 19. A Boring by Jumper.

the enemy, who can no longer advance in the shattered earth. The aggressor is obliged to begin again and to recommence behind and to one side. He has lost time and labor.

A Greek author, Æneas, who appears to have lived in the reign of Philip II, father of Alexander the Great, related that Amasis, King of Egypt, besieging the City of Barca (an ancient city of Cyrenaica, some ruins of which remain standing in Talomita) opened a subterranean passage, which caused much embarrassment to the besieged. They thought the enemy was already in the city, but they did not know where he was digging. In this extremity a coppersmith devised an expedient: taking a brass shield, he marched around the city pressing it to the ground at every step he took and pressing his ear against it. Where he heard no noise he judged that the miners were not working. Finally, arriving above the spot where the miners were, he heard them working. The inhabitants dug a gallery nearby and it was not long before they came together; those from the city, having the upper hand, killed and chased off the besiegers . . .; it would be rash to affirm that afterwards much progress was made in this direction. (A. Genez, *Historique de la guerre souterraine.*)

Editorial Note

Since the war began, the object of the MEMOIRS has been to give to Engineers and others in and out of the military service as much information as practicable about the work and duties of engineers in time of war. We have assembled a large army and are training it in the duties of an officer and a soldier. The art of war is perhaps more complicated than any other, more interesting and more absorbing. There is hardly a limit to the study that can properly be given it.

The duties of a military engineer include the construction of permanent and field fortification in all its branches, of roads, railroads, rivers, harbors, bridges, etc., the survey of the theatre of operations, the preparation of camps and battlefields, camouflage, sapping and mining, the use of tanks, explosives, searchlights, gas, etc., and of all technical work not especially assigned to another branch of the service. The engineers must know how to march, camp, and fight as infantry, and take their place on the firing line whenever opportunity offers. To build trenches they must know the nature and effect of artillery fire and the requirements for the proper service of the guns. They must know enough of hygiene to make the works sanitary.

The attack and defense of an entrenched position is essentially an engineer operation identical in its principles, but differing in form and dimensions from the attack and defense of an ancient castle. In the open field, engineers with their topographical training work with the cavalry and aviators in reconnaissance, and, on the staff, are especially useful in estimating the enemy's position and strength and in conveying the orders of the commanding officers to their troops.

All branches of the service should have a general knowledge of engineering, for its scope is so great on a modern battlefield that the engineers can only give general advice or supervision. The troops of other branches are often forced to plan as well as to build their own

trenches, forts, roads, railroads, and bridges, and attend to the work for which the engineers are especially equipped. The art of war depends more perhaps than any other upon coöperation. In modern warfare all services are so blended together that each must understand the work of the others.

The title of the PROFESSIONAL MEMOIRS probably indicates that its articles describe work worthy to be remembered, each contains also one brief memoir, usually of three or four pages with a portrait of some officer of the Corps who has been eminent for his work in civil or military life.

Most of the articles in the last four numbers of the MEMOIRS describe the most recent applications of civil engineering to warfare. Some give each a general and perspective view of some branch of the work of the military engineer. The numerous illustrations make the text much clearer. The design on the new cover suggests that in time of war engineers are glad to expose themselves to danger.

The article in the present number on the *liaison* of the engineers with other troops, by Commandant Rousseau of the French Army, gives an excellent account of the duties of engineers in the field.

The War Department has authorized the publication of articles on military subjects in the PROFESSIONAL MEMOIRS of the Engineers, and in the journals of the other branches of the service. These journals have published very interesting articles on engineering subjects. It is hoped that they may do so hereafter, that engineers may contribute to them articles relating to the work of the arm which each represents, and that officers of all branches of the service may contribute to the Engineer MEMOIRS. All are working to give to our new army all of the latest information on military subjects that can properly be published. If civil engineers will read these journals as well as our own, they will realize how much their own profession has in common with that of the modern soldier.

Before the war, the circulation of the MEMOIRS was mainly confined to the Corps of Engineers, almost all of whom were subscribers, and to civil engineers in and out of the Government service. In six months it has nearly doubled. The interest shown by the National Army is most gratifying and so is that of the National Guard. We regret that there are so few officers of other branches of the regular Army among the subscribers, which is doubtless

mainly due to the fact that they do not fully understand its scope.

Almost all the articles now relate to subjects in which other branches are directly interested. We hope that our readers will lose no opportunity to explain the error which may, in part, be due to the fact that the old title has been retained. It is understood that the question of a change in the title is now under consideration. —Col. W. R. Livermore, United States Army, Retired, Editor.

Poisonous Gas in Warfare

APPLICATION, PREVENTION, DEFENSE, AND MEDICAL TREATMENT.

A SHORT, ANNOTATED BIBLIOGRAPHY OF GASES AND KINDRED DEVICES APPLIED IN THE PRESENT WAR. PREPARED BY HENRY E. HAFERKORN, ENGINEER SCHOOL LIBRARY, ASSISTED BY FELIX NEUMANN, SURGEON-GENERAL'S OFFICE LIBRARY.

PART II.

January 15, 1918.

PREFATORY NOTE.

The following titles which have been prepared since October, 1917, when the first part of this Bibliography was published, are considered of sufficient importance to make them more easily available.

The same abbreviations have been used as in the first part, viz:

AW: Army War College Library, Washington Barracks, D. C.
CA: U. S. Coast Artillery School Library, Fort Monroe, Va.
ES: Engineer School Library, Washington Barracks, D. C.
LC: Library of Congress, Washington, D. C.
SG: Surgeon-General's Office Library, 7th and B Streets, S. W., Washington, D. C.
IMD: Articles Reviewed in the International Military Digest.

In nearly every case the call-number of the Library of Congress is added, which is also the case in a few entries of books on shelves of the Army War College Library.

In the absence of any of the above initials the title entry was considered important, but the book itself cannot be found in any of the libraries of Washington.

Additional references to the above subject will appear in future numbers of the PROFESSIONAL MEMOIRS, under the Articles of Engineering Interest.—H. E. H.

A. Books.

NOTE.—Entries marked thus * have been supplied by Mr. H. H. B. Meyer, Chief Bibliographer, Library of Congress.

The call-numbers are given in parenthesis at end of title.

179 BERTHELOT, MARCELIN PIERRE EUGENE.

Histoire des sciences. La chimie au moyen âge. Ouvrage publié sous les auspices du Ministère de l'instruction publique par M. Berthelot. . . . Paris, Imprimerie nationale, 1893. 3 v. illus. 28½x23cm.
LC. (QD25 B56)

Contents.—t. i. Essai sur la transmission de la science antique au moyen âge. Doctrines et pratiques chimiques. Traditions techniques et traductions arabico-latines, avec publication nouvelle du Liber ignium de Marcus Graecus et impression originale du Liber sacerdotum.—t. ii. L'alchimie syriaque comprenant une introduction et plusiers traités d'alchimie syriaques et arabes d'après les manuscrits du British museum et de Cambridge. Texte et traduction.—t. iii. L'alchimie arabe comprenant une introduction historique et les traités de Cratès, d'El-Habib, d'Ostanès et de Djâber, tirés des manuscrits de Paris et de Leyde. Texte et traduction.

180 BERTHELOT, MARCELIN PIERRE EUGENE.

Sur la force des matières explosives d'après la thermochimie. Par M. Berthelot . . . 3e édition (avec figures), revue et considérablement augmentée. Paris, Gauthier-Villars, 1883. ES.

2 v. incl. diagrs., illus., tables. 25 cm.

"Feu grégeois," v. i, p. 346. Appendice, v. ii, p. 352-363: Des origines de la poudre et les matières explosives. Projectiles incendiaires des anciens.—Feu grégeois—Le secret en est conu.

The first ed. of this work was published 1871, the 2d, 1872. An English translation was issued under the title: Explosives and their power. See No. 181.

181 BERTHELOT, MARCELIN PIERRE EUGENE.

Explosives and their power. Tr. and condensed from the French of M. Berthelot by C. Napier Hake and Mm. Macnab. With preface by Lieut. Col. J. P. Cundill. Lond., J. Murray, 1892. xi, [1], 563 p. illus. 23cm.
LC. (TP270. B53) ES.

181a BOUDREAU, L.

L'Iode contre l'action délétère des gaz asphyxiants. (Délabrements pulmonaires et délabrements généraux. Paris, 1917. 1 fr.

182 BROUARDEL, PAUL CAMILLE HIPPOLYTE.

Les asphyxies par les gaz, les vapeurs et les anesthésiques. Paris, J. B. Baillière et fils, 1897. vii, 416 p. 8 plates. 24cm. SG.

183 BROUARDEL, PAUL CAMILLE HIPPOLYTE.

Le laboratoire de toxicologie. Méthods d'expertises toxicologiques; travaux du laboratoire. Par P. C. H. Brouardel et J. Ogier. Paris, J. B. Baillière et fils, 1891. 224 p. 24cm. SG.

184 *CEVIDALLI, A.

Asphyxies et gas asphyxiants; moyen d'y remedier. Paris, Dunod et E. Pinat, 1916. 72 p.

185 DELORME, EDMOND.

Traité de chirurgie de guerre. Histoire de la chirurgie militaire française; plaies par armes à feu des parties molles. Paris, F. Alcan, 1888-93. 2 v. viii, 668; 1018 p. 24cm. SG.

186 DION, S. A.

Tanks, gas, bombing, liquid fire, by Capt. S. A. Dion. N. Y., Geo. U. Harvey, inc., c1917. 3 p. l., 156, [3] p. illus. 14½cm. (Harvey Military series). LC. (UF765 .D6)

Contents.—Bombs and grenades, p. 1-90. Trenches. Description of an average system of trenches, p. 91-110. Demolitions, p 110-128. Explosives, p. 110-128. Sapping, p. 129-130. Tanks, p. 131-137. Gas. Gas helmets and their use, p. 138-155. Gas attacks, p. 146- Protection against gas, p. 150-155. Liquid fire attacks, p. 156.

187 ENCYCLOPAEDIA BRITANNICA. 11TH EDITION.

Cambridge, Eng., New York, University press, 1910. ES. LC.

Greek fire, v. xii, p. 492-493.

Greek fire, Application by the ancients under Joinville, Jean, Sire de, v. xv, p. 492, 2d column.

188 FRÖHNER, EUGEN.

Lehrbuch der toxikologie für thierärzte. Stuttgart, F. Enke, 1890. viii, 256 p. 24cm. SG.

189 GAUTHIER, VINCENZO.

Manuale di tossicologia ad uso dei medici, farmacisti e studenti. Milano, F. Vallardi, [1898?] xii, 462 p. 1 l. 24cm. SG.

190 GLAISTER, JOHN.

Gas poisoning in mining and other industries. By J. Glaister and David D. Logan. Edinburgh, E. & S. Livingstone, 1914. 484 p. 22cm.

190a GREAT BRITAIN. ARMY. MEDICAL DEPT.

Medical and surgical history of the British army which served in Turkey and the Crimea during the war against Russia, 1854-56. Lond., Harrison and sons, 1858. 2 v. fold. maps. 33½cm. (Parliament. H. of C. Sessional papers, 1857-58, vol. xxxviii, pts. 1, 2.)

LC. (J301 K6. Sess. papers v38).

Contents. i. Medical history of individual corps. Medical topography and diseases of Servia, Bulgaria, etc. Climate and disease of Roumalia. ii. History of diseases and of wounds and injuries—Topography and climate of Bulgaria and the Crimea.

191 GREAT BRITAIN. FOREIGN OFFICE.

Correspondence respecting the second Peace conference, held at the Hague in 1907. [With references to ''Miscellaneous No. 1 (1899)].'' Presented to both houses of Parliament by command of His Majesty. January, 1908. Lond., Printed for H. M. Stat. off., by Harrison and sons, [1908]. 1 p. l., 180 p. 33½cm. (Miscellaneous, No. 1, 1908) Parliament. Papers by Command. Cd. 3857. LC. (JX1913. A4. G7.)

191a GREAT BRITAIN. ROYAL COMMISSION ON THE SANITARY CONDITION OF THE ARMY, 1857.

Report of the commissioners appointed to inquire into the regulations affecting the sanitary condition of the army, the organization of military

hospitals, and the treatment of the sick and wounded; with evidence and appendix . . . Lond., Printed by G. E. Eyre and W. Spottiswoode, for H. M. Stat. office, 1858. 2 v. fold. plans, diagrs. (part fold.) 33½cm. Parliament. H. of C. Sessional papers, 1857-58, vol. xviii-xix. LC.

Added t.-p. Reports from commissioners: fifteen volumes. i. Army Sanitary conditions.

Vol. 2 (Appendix lxxix) includes copies of letters written and received by the director general of the Army medical dept., and other officials, relating to the health of the troops, and the sanitary condition of hospitals in Bulgaria, the Crimea, and Scutari, during the war in the East, 1854 to 1856.

192 *Hague. International Peace Conference.

The Hague declaration (iv, 2) of 1899 concerning asphyxiating gases. Washington, D. C. The Endowment, 1915. 2 p. 25cm. Carnegie endowment for international peace. Division of international law. Pamphlet No. 8). LC. (JX1906. A3, No. 8; JX5133. G3H3).

193 Hague. International Peace Conference. 2d, 1907.

Acte final de la deuxième Conférence de la paix suivi d'un index alphabétique et analytique, par Fréd. Bajer . . . Monaco, Institut international de la paix, 1908. 139 p. 2 l. 21½cm. (Publications de l'Institut international de la paix, No. 10). LC. (JX1913. A358).

194 Hague. International Peace Conference. 2d, 1907.

Final act of the 2d peace conference, held at the Hague in 1907; and conventions and declaration annexed thereto. Presented to both houses of Parliament by command of His Majesty. July, 1908. Lond. Printed for H. M. Stat. office, by Harrison and sons [1908]. 1 p. l., 149 p. 33½cm. (Miscellaneous, No. 6, 1908). Great Brit. Parliament. Papers by command. Cd. 4175. French and English text. LC. (JX1913. A36).

195 Hague. International Peace Conference. 2d, 1907.

Protocol of the eleven plenary meetings of the Second peace conference, held at the Hague in 1907. With the annexes to the protocols. Presented to both houses of Parliament by command of His Majesty. June 1908. Lond., Printed for H. M. Stat. office, by Harrison and sons [1908]. viii, 546 p. fold. tab. 33½cm. (Miscellaneous, No. 4, 1908). Great Brit. Parliament. Papers by command. Cd. 4081. LC.

196 Haldane, John Scott.

Methods of air analysis. With 24 illustrations, including one plate. Lond., C. Griffin and Co., lim., 1912. X, 130 p. illus., fold. plate. 20cm. (Griffin's scientific textbooks). LC. (QD121. H3).

197 Hime, Henry William Lovett.

Gunpowder and ammunition. Their origin and progress. By Lt. Col. H. W. Hime (late R. A.). Lond., [etc.], Longmans, Green & co., 1904. ES.

V. ii. chap x. Firearrows and fire-pikes, p. 168. Hand grenades, p. 169. chap. xi. War rockets, p. 172. chap. xiv. Igneous projectiles: Hot shot, p. 217. Incendiary fireballs, p. 217. Incendiary shell, p. 220. Carcasses, p. 244. Explosive fireballs, p. 244. Explosive shell, 225. xv. Igniters: Hot wires,

priming powder matches, and portfires, p. 288. Table of Greek fires, p.32. Table of sea-fires, p. 41. Greek-fire, chap. iii., p. 29-56.

A new edition of this book was printed with the title: "Origin of artillery. Ibid., 1915. 231 p. 23 cm. LC. (U883. H5.)

Greek-fire, p. 28. Incendiary fireballs, p 189-192. Incendiary shells, p. 192-194.

Most of the second part of the book has appeared in serial form in the Proceedings of the Royal Artillery Institution, see No. 217.

198 *HIME, HENRY WILLIAM LOVETT.

The origin of artillery. Lond., N. Y. [etc.] Longmans, Green & co., 1915. LC. (U883. H5).

viii, 231 p. front. 22½ cm.

"Partis i and iii of this book are a second and revised edition of Gunpowder and ammunition, which is now out of print. Much of part ii has been taken (by permission) from my article entitled "Our Earliest Cannon," which appeared in the Journal of the Royal artillery, vol. xxxi."

"Books often quoted": p. 221.

199 INSTITUT INTERNATIONAL DE LA PAIX.

Deuxième Conférence de La Haye; opinions, projets, propositions diverses . . . Monaco, Institut international de la paix, 1907. 107 p. 2 l. 21x11cm. (Publications de l'Institut international de la paix, No. 5). LC. (JX1916. J6).

200 LALANNE, LUDOVIC I. E. MARIE LUDOVIC CHRETIEN.

Recherches sur le feu grégeois, et sur l'introduction de la poudre à canon en Europe; mémoire auquel l'Académie des inscriptions et belles-lettres à décerne une médaille d'or, le 25 sept., 1840; par Ludovic Lalanne . . . 2.éd. cor. et entièrement refondue. Paris, J. Corréard, 1845. 96 p. 28x23cm. LC. (TP268. L2).

201 MARSHALL, ARTHUR.

Explosives. 2d. ed. Philadelphia, Pa., P. Blakiston's son & co., 1917. 2 v. front. (port.) illus. 25½cm. Printed in Gt. Britain. LC. TP270. M25, 1917. ES. AW.

202 MATTHEW, T. O. Reports, letters, etc., see in Nos. 190a, 191a.

203 PRUSSIA. KRIEGSMINISTERIUM.

Handbuch der waffenlehre. Für offiziere aller waffen zum selbstunterricht, besonders zur vorbereitung für die Kriegs-Akademie. Berlin, E. S. Mittler & sohn, 1911.

The same. Die neuerungen der handfeuerwaffen und maschinengewehre. Zugleich 1. Nachtrag zum Handbuch der waffenlehre. Berlin, E. S. Mittler & sohn, 1906.

204 REINAUD, JOSEPH TOUSSAINT.

Histoire de l'artillerie, 1re partie. Du feu grégeois, des feux de guerre et des origines de la poudre à canon d'après des textes nouveaux; par M. Reinaud . . . et M. Favé . . . Paris, J. Dumaine, 1845. 2 p. l., 285. [5] p. 22½cm. and atlas of xvii pl. 27x23cm. LC. (TP268. R36). No more published.

205 Roberts, A. A.

The poison war, by A. A. Roberts . . . Lond. W. Heinemann, [1915]. 143, [1] p. illus. 22½cm. Bibliography: 1 p. at end. AW.

Contents.—i. Asphyxiation in warfare. Nitric-peroxide. The Hague Convention error. American views. Torture in warfare. The German offense summarized. The French ''75'' shell in comparison with the German ''77.'' The land poison gas machine. Carbon-monoxide. Chlorin and bromin. Sulphur dioxide. The naval poison-gas machine. Blowing up the enemy. Restoring the asphyxiated. The pulmotor. The oxygen helmet. Hand grenades and bombs, p. 13-48. ii. The Allied troops being systematically poisoned by the Germans in a manner publicly unknown. The Hague Convention and usage of poison in warfare. The Romans and the Germans. Cases of poisoning. Its subtle method of administration, p. 49-68. iii. The German long-range poison, its history, nature and effect, p. 69-82. iv. Baron de Bieberstein on automatic contact mines. Gun-cotton, its history and composition. T. N. T. German ''Triplastik.'' Cordite and naval disasters. Tolite. Cresylite. Melinite. Lyddite. Picric acid. The Turpin explosives. Mining explosives in warfare, p. 83-102. v. Liquid-fire sprays. Incendiary bombs. Shells and pastilles; their history and composition. Zeppelin bombs. Thermit, p. 103-117. The German high-explosive and shrapnel shell combined. The Casualties of war. Percentage of mortality amongst officers. Historical tables. Percentage of losses in battle from 1704 to 1870. Ratio of killed to wounded in wars, 1864 to 1904. The Balkan war. Increase of bayonet wounds, p. 118-126. Appendices. i. Regulation respecting the laws and customs of war on land, p. 127-128. ii. Concerning the laws and customs of war on land, p. 129-130. iii. Declaration respecting asphyxiating gases, p. 131-133. iv. Convention (No. 8) relative to the laying of automatic submarine contact mines, p. 134-135. v. Sir J. Pauncefote to the Marquess of Salisbury, p. 140-141. vi. Memorandum, from Sir J. Fisher to the Marquess of Salisbury, July 20, 1899, upon the question of asphyxiating gases, p. 142-143. Bibliography, p. 144.

Plates. 1. The explosive poison tube of a German ''77'' shell, p. 12. 2. The German poison-gas machine, p. 25. 3. The German naval poison-gas machine, p. 35. 4. The pulmotor, p. 41—4A, 4B. The oxygen helmet, p. 42, 43. 5. Apparatus for throwing a grenade from a rifle instead of by hand, p 47. 6. The shrapnel bullet poison-box, p. 63. 7, 8. The German shrapnel bullet and the poisoned bullet, p. 64. 9. The German ''Liquid-fire'' spray, p. 104. 10. The German high explosive and shrapnel shell combined, p. 119.

206 United Gas Improvement Co., Philadelphia, Pa.

First aid for persons overcome by gas. 4th ed., Philadelphia, Firm, 1915. SG.

207 Wescher, Carle.

. . . Poliorcétique des Grecs. Traités théoriques.—Récits historiques. Ouvrage publié par l'Imprimerie impériale. Textes restitués d'après les manuscrits de Paris, du Vatican, de Vienne, de Bologne, de Turin, de Naples, d'Oxford, de Leyde, de Munich, de Strasbourg, aug-

mentés de fragments inédits, et accompagnés d'un commentaire paléographique et critique, par C. Wescher . . . Paris, Imprimerie impériale, 1867. 3 p. l., xliv, 388 p. illus. 29x20½ cm. Greek and French text. LC. (UG443. W51.)

208 WISE, THOMAS A.

Commentary on the Hindu system of medicine. Calcutta, 1845; the same, Lond., Trübner & co., 1860. 24cm.

209 WITTHAUS, RUDOLPH AUGUST.

Manual of toxicology. Reprinted from "Whitthaus' and Becker's medical jurisprudence, forensic medicine and toxicology. 2d ed. N. Y., W. Wood & co., 1911. ix p. 1 l. [5]-1261 p. illus. 25cm.
LC. (RA1211. W6.) SG.

B. Periodicals

210 A PROPOS DES GAS ASPHYXIANTS.

Bulletin Générale de Thérapeutique Medicale et Chirurgale, Paris. v. clxviii, 1914, p. 499. SG.

211 THE BEST DEFENSE AGAINST CHLORINE. FORMULA.

Scientific American, N. Y. v. 113, No. 22, Nov. 27, 1915, p. 465. 160 words. AW. LC. (IL. S5.)

212 *BERTHELOT, MARCELIN PIERRE EUGÈNE.

Les compositions incendiaires dans l'antiquité et au moyen âge. Le feu grégeois et les origines de la poudre à canon. Revue des deux Mondes, Paris. xlie année, 3e période. v. 106, 4e livraison, 15 août, 1891, p. 786-822. LC. (AP20. R3, 3 pér. v. 106.)

213 *BIGG, E.

Notes on three cases of chlorine gas poisoning. Lancet, Lond., v. 2, 1916, p. 341. SG.

214 BUSINCO, A.

I gas cosi detti asfissianti in guerra. (Brevi considerazioni storich, cliniche, profilattiche, anatomiche e chimiche). Rivista di Medicina Legale, Pisa. v. vi, 1916, p. 337-343. SG.

215 *CANADIANS AT YPRES.

Broad Arrow, Lond., v. xciv, No. 2445. May 7, 1915, p. 511-513. Diagrs. LC. (U1. B8, v. 94.)

Illustrations. [1] Position before discharge of gas. [2] Position after. [3] Position on Friday morning.

216 *CHAPMAN, J. B. W.

Poison gas. Letter to editor. Nation, Lond., v. xvii, No. 16. July 17, 1915, p. 513. LC. (AP4. N15, v. 17.)

217 DE DOMONINICIS, A.

Sulle imperasfissie da idrogeno solferato ed acido cianidrico. Il Cesalpino, Giornale medico, Arezzo, Italy. v. xiii, 1917, p. 37-39. SG.

218 EMPLOYMENT OF ASPHYXIATING GAS.

Army and Navy Register, Wash., v. 58, No. 1832, Aug. 28, 1915, p. 269. AW. LC. SG.

From "Le Temps," May 9, 1915.

This is a report published by the "Official Journal," and which was presented to the President of the Council by a Special Commission of Investigation. Signed G. Payelle, Chairman.

219 *ENGINS DE TRANCHÉES ALLEMANDS, PRIS EN CHAMPAGNE. L'Illustration, Paris. v. 146, No. 3792. Nov. 6, 1915, p. 483. Illustrations with letterpress. LC. (AP20. I3, v. 146.)

Showing the use of poison gas by Germans, and containers applied.

220 AN EYEWITNESS OF THE "GAS-BATTLE" AT YPRES. Literary Digest, N. Y. v. 51, No. 10, whole 1324. Sept. 4, 1915, p. 483-485. ES. AW. LC. (AP2. L58, v. 51.)

221 *A FIGHT AGAINST GAS. BY A BRITISH OFFICER. Harper's Weekly, N. Y. v. lxi, No. 3067, Oct. 2, 1915, p. 323. 2 half-tones. LC. (AP2. H32, v. 61.)

Illustrations: In a British trench after a gas attack.

222 *FIGHTING THE WAR-GAS. Literary Digest, N. Y. v. li., No. 2, whole 1316. July 10, 1915. 3 illus. LC. (AP2. L58, v. 51.)

Illustrations. [1]. Successful types of respirators. The French "Masque Robert." Another French mask, the "Detourbe," in detail. New British device. [2]. A sample type of French gas-mask, but a success. (Shows construction in detail, as described in the accompanying article.) [3]. The unsuccessful British gas-mask.

223 *FIGHTING WITH FUMES—A HUMANE INNOVATION? Editoral. The Independent, N. Y. v. 82, No. 3466, May 10, 1915, p. [227]-228. LC. (AP2. I 53, v. 82.)

224 *FILIPPINI, A.

La difesa contro i gas asfissianti. Annali d'Igiene, Roma, v. 26, 1916, p. 705-713. SG.

225 *GAS BOMBS. THE GERMAN PREPARATIONS. Army and Navy Gazette, Lond., v. 56, No. 2886. May 8, 1915, p. 412. AW. LC. (U 1 +A65, v56.)

Methods of using asphyxiating gases. Report by the Belgian Legation, dated April 24, 1915, to the Commission of Inquiry on the Relations of the rules of the rights of nations, and of the laws and customs of war, communicated to the Press Bureau.

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Engineering and Mining Journal, N. Y. v. 103, No. 20, May 19, 1917, p. 906-907. LC. (TA 1 E56, v. 103.)

227 *LES GAZ ASPHYXIANTS. Annales d'Hygiène Publique, Paris. 4e série, v. 24 1915, p. 162-175. SG.

228 GERMAN GAS-ATTACKS. Literary Digest, N. Y. v. 55, No. 2, whole 1421, n. s., July 14, 1917, p. 37, 38, 40. LC. (AP2. L58, v.55.)

Under "Personal glimpses." From an article by Sterling Heilig, in the Times-Picayune, New Orleans, La.

229. GERMAN IMPROVEMENTS IN "FLAMMENWERFER."

The Illustrated War News, London. New series, part 65, Sept. 5, 1917, p. 37. AW. Monthly List, Oct., 1917. Item 188.

Illustration with letterpress: "The Life buoy." German flame-projector. Canadian officers inspecting an apparatus.

230 *German Methods Of Gas Attack In Poland.
The Times, Lond., Weekly edition. June 18, 1915, p. 530.

231 *German Use Of Gas. Army and Navy Gazette, Lond., v. 56, No. 2886. May 15, 1915, p. 424. 400 words. AW. LC. (U 1 A65, v. 56.)

232 *Giroux, L.
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234 *Greek Fire. Chambers' Journal, Lond., 3d ser. v. 20, Oct. 24, 1863, p. 260-261. LC. (AP4. C45, 3d ser., v. 20.)

235 Gremeaux, P.
Lésions oculaires consécutives à l'action des gaz lacrymogenes. Progrès Médical, Paris. 3e série, v. xxxi, 1916, p. 157. SG.

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Lethal gases in war. Official report of Dr. J. S. Haldane on the gases used by the Germans, war of 1914-15. The Times, Lond. Weekly edition. v. 39, April 30, 1915, p. 362. SG.
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237 *Hebbletwaite, A. S.
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238 *Henderson, Yandell.
Carbon monoxid poisoning. By Yandell Henderson, Professor of physiology, University school of medicine, New Haven, Conn. American Medical Association, Chicago. Journal, v. 67, No. 8, Aug. 19, 1916, p. 580-583. LC. (R15. A48.) SG.

239 *Hill, L.
Gas poisoning; pathological symptoms and clinical treatment. Medical Society, Lond., Transactions, v. 39, 1915-16, p. 102-120. SG.

240 *Hiltmann, E.
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Our earliest cannon, 1314-1346. By Lt. Col. H. W. L. Hime, (late R. A.) Royal Artillery Institution. Minutes of proceedings. v. xxxi, No. 12, p. 489-494. 2 diagrs. ES. LC. (UF1W8.)
See also No. 186, Gunpowder and ammunition by the same author.

242 Ilyin, A. V.
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243 *Kershaw, John B. C.
The war from a chemist's and engineer's standpoint. i. The use of poisonous gases by the Germans in trench warfare. Army and Navy Gazette, Lond., v. 56, No. 2889, June 5, 1915, p. 496-497. AW. LC. (U1. A65, v. 56.)

244 LESLIE, R. M.
The effects of the poisonous gases used by the Germans. The Clinical Journal, Lond., v xliv, 1915, p. 249-253. SG.

245 *LÉVY, F.
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246 *LIAN, C.
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La Nature, Paris. v. 43, ptie. i, No. 2173. 22mai, 1915, p .338-340. 2 figs. LC. (Q2. N2, v. 43.)

Signed Drs. D. and O.

Fig. 1 La confection des masques contre les vapeurs. Fig. 2 Le masque et son armature metallique.

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Signed W. T. B.

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Numbers Refer to Numbers Before the Authors' Name, or Before the First Word of the Title.

MAJ. GEN. JOHN G. PARKE

1827-1900

CONCRETE PAVED BANK REVETMENT, MISSOURI RIVER IMPROVEMENT.

By

Mr. G. C. Haydon,
Assistant Engineer; M. Am. Soc. C. E.

Improvement of the Missouri River by the United States Government, by means of works designed for the contraction of channel widths and bank protection, began as early as 1876.

The successful protection of caving banks is the foundation of the improvement of the river, and has been the great study to those engaged on the work. This study, combined with trials and experiments with many types of work, resulted in the evolution of what is known as "Standard Revetment" . . . This consists of a continuous woven willow brush mattress ballasted to cover the bank below the water line and, on the river bed, for protection of the subaqueous bank, the upper sloped bank being covered with a rough pavement of one-man riprap stone. It has generally been found that, from the use of this type fair results have been obtained, due, perhaps, to the fact that it readily adjusts itself to any disturbance of its foundation which may reduce the extent of the disturbance, and because it lends itself to repair which can readily and economically be made in its incipiency. The estimated cost of the standard type is $10 per linear foot for completed work. For general plan, see Plate I.

Concrete Paved Bank. . . . There seems to be no record of any claim for the first experiment in protecting the slope of a river bank by paving it with concrete, although it was used as early as 1897 in protecting the toe of the slope for the Holland dikes, and in 1900 by the Corps of Engineers, U. S. Army, for the upper bank paving in river improvements.

This type is somewhat like a monolithic structure and tends to lose the advantage of automatic adjustment to slight changes in the foundation, so that there is a constant uncertainty as to its condition and a possibility of a serious collapse in after years.

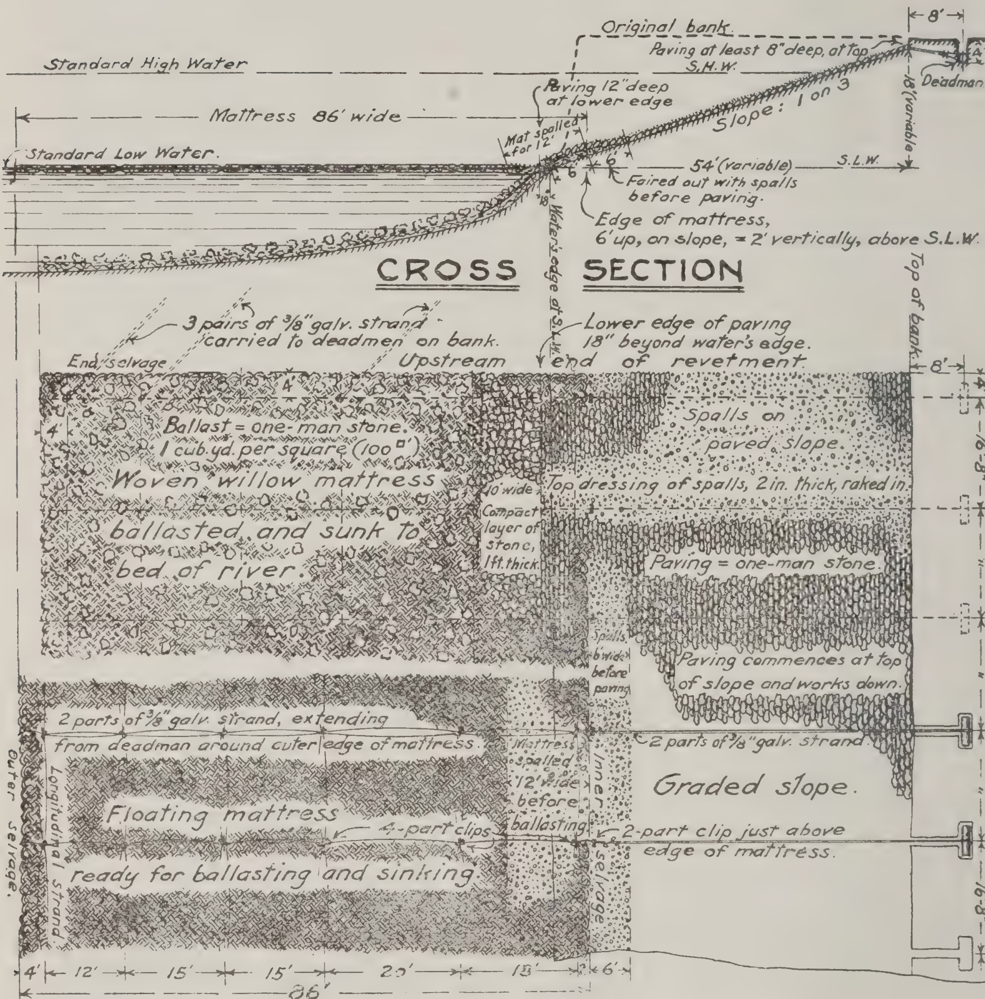

Plate I. General Plan, Standard Revetment. (Missouri River Improvement. U. S. Engineer Office, Kansas City, Mo., 1916.)

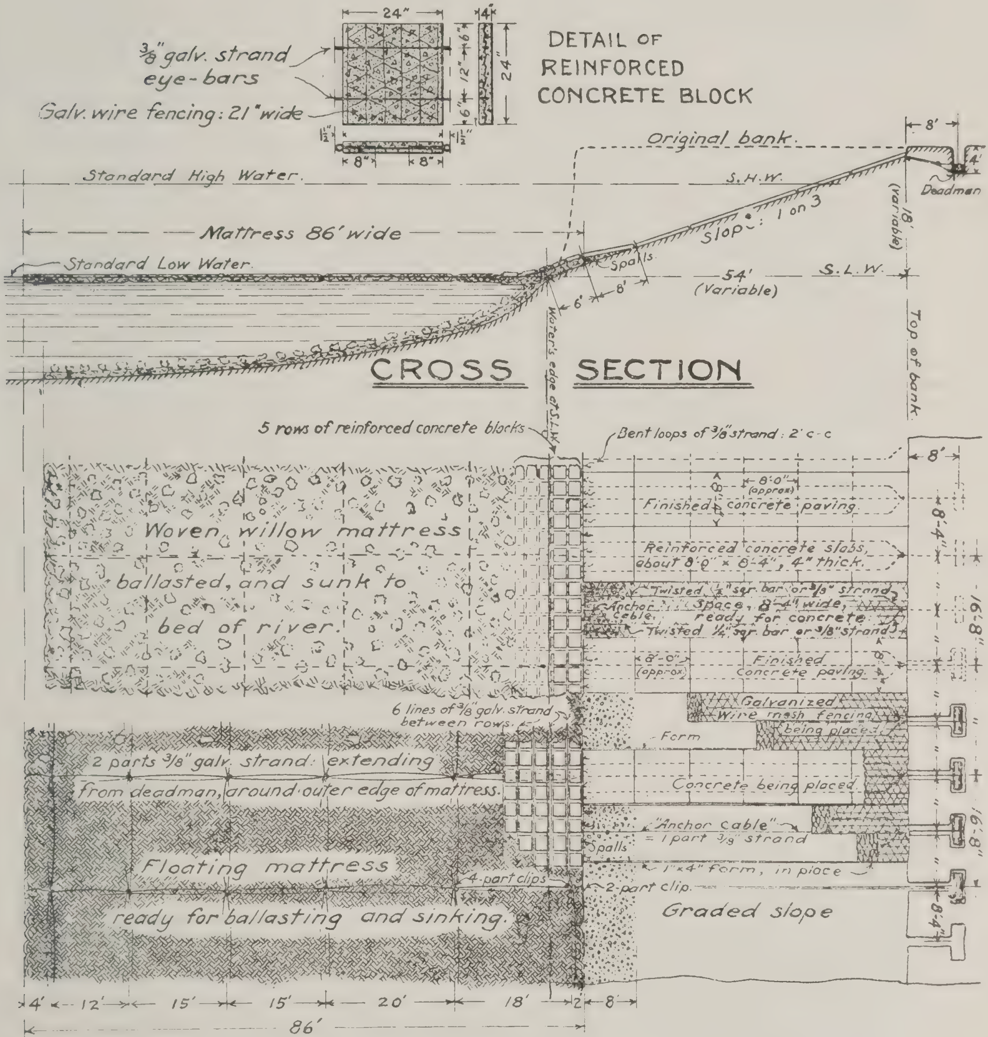

Plate II. General Plan, Combination Concrete and Willow Mattress Revetment. (Missouri River Improvement. U. S. Engineer Office, Kansas City, Mo., 1916.)

This revetment is a departure from the standard type used on the Missouri River in that the upper bank is paved with a 4-inch layer of reinforced concrete slabs instead of broken stone, and the subaqueous willow mattress protected for about 10 feet width from the shore edge, with reinforced concrete blocks connected to the solid upper pavement, and so laced and tied together with wire strand within themselves as to form a flexible covering instead of the compact layer of stone for the same width. For the general plan, see Plate II.

The concrete paved bank revetment, selected for description, is known as the Bates Island Bend revetment, located on the right bank of the river at mile 98, above the mouth.

It was the first piece, of any magnitude, constructed on the river in which machinery and a system of organization for progress was used, and comprises 14,188 feet of finished work at $7.58 per linear foot. It was begun in March, 1912, and completed September 8, 1913, by hired labor and Government plant.

Plant. The plant used on the work consisted of the following: One double-decked quarterboat with a capacity of housing from 60 to 70 laborers and necessary foremen, 1 hydraulic grader, 1 mattress barge, 1 barge for concrete mixer plant, 6 material barges, and 1 tow boat. The working plant was supplemented by an 8-inch suction pump, installed on a material barge, for procuring gravel. The value of this plant is estimated at $60,000, no charges having been made for depreciation.

Material. The principal material used, which was procured locally and delivered by barge, consisted of willow brush at $1.60 per cord; stone at $0.68 per cubic yard, and sand and gravel at $0.08 per cubic yard; manufactured material delivered by freight consisted of 3/8-inch galvanized strand at $0.71 per linear foot; 50-inch galvanized woven fence wire, for the paving, at $0.06 per linear foot; 22-inch fence wire, for blocks, at $0.03 per linear foot; lumber, for forms, at $22 per M. b. m., and Portland cement at $0.75 per bbl. (f. o. b. factory). The gravel for the concrete paving and blocks was procured from the Gasconade River about 2 miles above the mouth, and delivered on barges by an 8-inch suction pump. It is a natural mixture of clean sand and gravel, the latter ranging in size from a 1/4-inch to 3-inch pebble; it was impracticable to keep an itemized cost of procuring this gravel as it was in conjunction with other items of construction.

Fig. 1. Typical concave bank.

Fig. 2. Hydraulic grading of bank; slope 1 on 3.

The cement used was of the American Portland brand. The finished aggregate is of a 1-2-4 mixture.

The 3/8-inch diameter galvanized strand is composed of 7 No. 11 wires, having a tensile strength of about 5,000 pounds.

The reinforcing for the paving consists of galvanized woven-wire fabric, diamond mesh 50 inches wide, formed of 13 No. 10-gauge line wires uniformly spaced, with No. 12½-gauge stay wires at 4-inch intervals; elastic limit 75,000 pounds to the square inch. In addition to the woven-wire fabric, and the mattress 3/8-inch anchor strands, similar strands for block fastenings are spaced 16⅔ feet, which gives a 3/8-inch strand reinforcing every 8⅓ feet, in the slab, anchored to a deadman on top bank.

The reinforcing for the concrete blocks consists of 22-inch woven-wire fabric, similar to that used in the paving. In addition to the woven fabric, two 3/8-inch strands are placed with an "eye loop" at each end for joining the blocks. These blocks, $2' \times 2' \times 4''$, were made at a central yard at a cost of 28 cents each, and delivered by barge at site of the work.

In the construction of revetment the work is practically divided into 3 general classes: first, grading; second, mattressing; and third, paving. In the matter of cost accounting, the 2 latter classes are subdivided into the necessary heads for determining the expenditures of procuring, delivering, and placing the material. As these are usually variable quantities fixed by accessibility and the law of supply and demand, these detailed headings will be omitted. . . . For a typical concave bank see Fig. 1.

Grading. The bank is graded by the hydraulic method to 1 on 3, which gives a length of slope from 42 to 54 feet according to height above standard low water, which also determines the length of a slab. (Fig. 2.)

Mattress. After the bank is graded the continuous mattress, 86 feet wide, is woven of bar-growth willows, from ½ to 2 inches in diameter at the butt end and 10 to 25 feet long. The header, about 12 inches in diameter, is formed by lapped bundles of willows bound together to the desired width of mattress, by 3/8-inch strand. The stitch is then started by inserting single willows into the bundle at an angle of about 45 degrees, from one end of the header to the other; then the willows are inserted at the same angle in the reverse direction, the last willow inserted being on top (Fig. 3). This makes the weaving a continuous over process, the stitch having an over and under appearance. The willows are placed in such num-

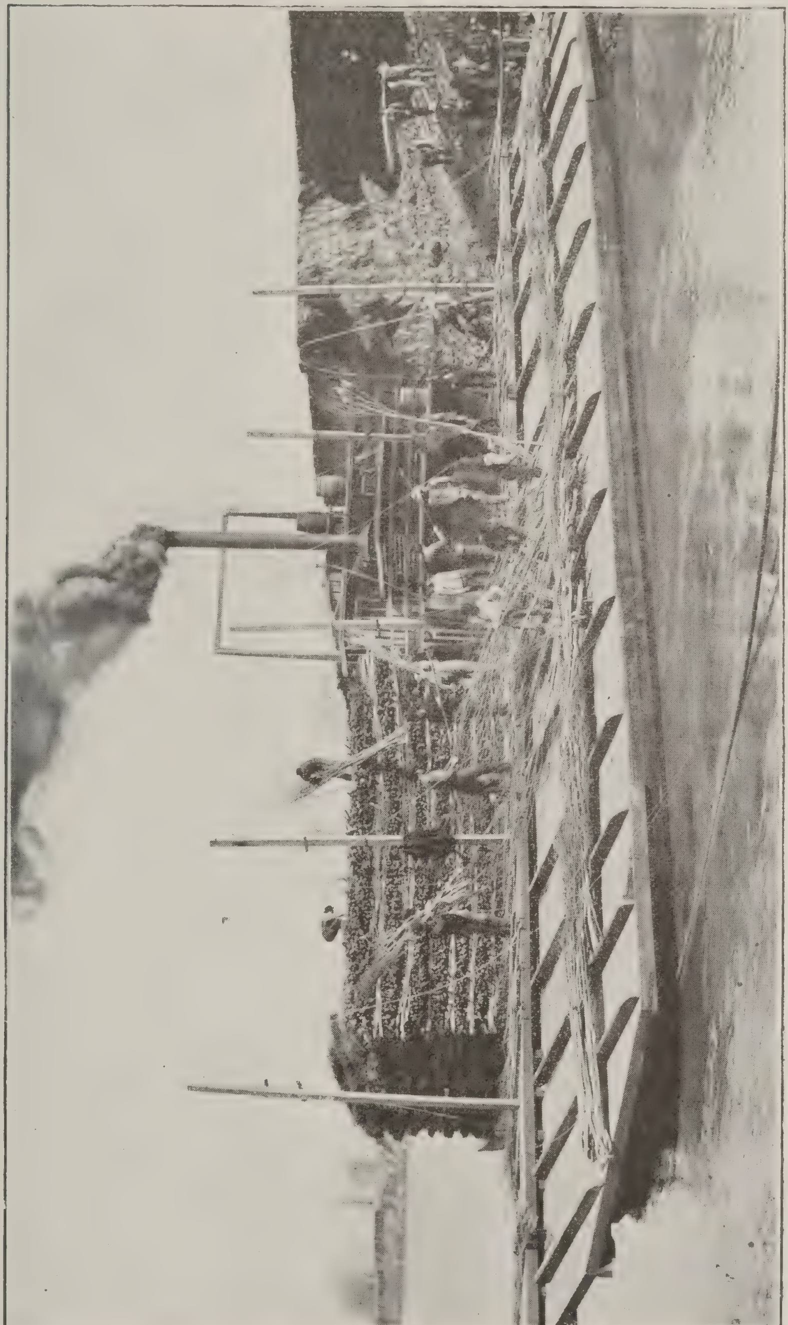

Fig. 3. Header for willow brush mattress; starting stitch.

bers and closeness of weave as to make a mattress 12 inches thick. As the weaving progresses a selvage is made along each side of the mattress by turning in the tops of the outer willows, or an equally good selvage (known as the "sidewalk") is made by platting willows, longitudinally along the edges.

The mattress is strengthened by a longitudinal and cross system of ⅜-inch in diameter galvanized strand. The longitudinal system for an 86-foot mattress consists of 6 pairs of strands, spaced as required, each pair consisting of 1 strand underneath and 1 strand on top of the mattress. The cross systems are in pairs, one underneath and 1 on top, spaced 16⅔ feet apart. At each intersection of the 2 strands underneath and the 2 strands on top, all 4 are drawn together tightly with a 7/16-inch, U-shaped clip, after all the slack has been taken out of the strands by block and tackle. The head of the continuous mattress, or any section of mattress, is anchored by 3 pairs of strands fastened to the respective longitudinal strands, 1 pair 4 feet, 1 pair 16 feet, and the remaining pair 46 feet back from the outer corner and run ashore at a 45° angle with the upper edge of the mattress and fastened to deadmen 50 feet back from the edge of the bank. The continuous mattress is anchored to the bank by each pair of cross strands carried up the slope and fastened to a deadman placed 8 feet back, and 4 feet below the top of slope.

It was planned to string the concrete blocks, forming the 10-foot width inshore mattress flexible protection, on 6 longitudinal ⅜-inch strands passed through the eye loops, but this method was found difficult and slow. A change was made for connection of the inside blocks by using short pieces of ⅜-inch strand passed through the eye loops and twisted into a clip. The changed plan required only 4 longitudinal strands; the 2 outside ones passed through the eye loops, the upper one serving to anchor the blocks to the paving, and the lower one to lock the system or hold the blocks *en masse;* the 2 inside strands laid along alternate joints are held in place by the twisted clips. The blocks are laid as close as possible, longitudinally, with no ties between. On account of the weight of the blocks, it was necessary to place them in advance of the paving and ballasting of the mattress and well up to the mattress barge and later anchor them to the paving.

In this way they also serve as the lower forming for the concrete slab. (Fig. 4).

The mattress is then ballasted with one-man stone of sufficient

quantity to cause it to be in good contact with and take the shape of the river bed, and to allow the mixing plant to come near the toe of slope.

Paving. After the bank is graded, and mattress woven and ballasted in place, the slope is prepared for the concrete paving. It is divided into panels 8 feet wide, from top of bank to water surface, by placing a forming of 1″×4″ plank on edge, held in place by small wooden pegs, the inside pegs being removed as the aggregate is placed; the panel is then divided into 8-foot sections by placing ordinary plastering laths across the panel, or longitudinally with the bank under the mattress and block anchor strands; this

Fig. 4. Placing concrete blocks. Mattress ready to ballast and preparing slope.

forming makes the joints of the slabs. At the foot of the paving additional short pieces of ⅜-inch strand are so placed as to provide the required number of fastenings for the 2-foot blocks. The reinforcing wire mesh is then laid in place by unrolling the bundle from top to bottom of slope and held in place by pegs (which are removed as the aggregate is placed), two widths to the panel, each overlapping about 3 inches along the middle line and cut off at the bottom to the required length.

The concrete mixer and delivery plant were installed on a barge, 30′×80′×4′ (mattress barge). The mixer was a standard make on skids; the delivery plant or cableway, consisted of a regulation 3-drum hoisting machine and stiff-leg braced mast, with top sheave for the hoisting cable carrying the mortar bucket. For convenience

in moving and to procure the proper land height the carrying end of the cable was passed over a wooden horse about 8 feet high. The mast and mixer were so placed that the bucket could easily pass to and from the discharge spout.

After the bucket was filled it was raised to proper height and traveled ashore by gravity; a reverse operation returned the bucket to the mixer. A movable stop block on the cable, held by dogs, marked the place desired, and a trip on the running sheave of the bucket coming in contact with the block automatically deposited the aggregate on the slope. (Fig. 5.) The method of depositing the aggregate as described above was later changed to the use of governing cables connected to the bail of the bucket, with a trip, worked by hand, to tilt the bucket. After experimenting for cable anchorage the following was evolved and proved very satisfactory: the carrying cable, after passing over the horse, was connected with a sheave and shackle so as to run in the bight of a double cable, about 350 feet long, running parallel to the bank and anchored to deadmen at each end. Two of these cables were provided, and when placed, were laid with the ends overlapping about 50 feet, so that the arrangement carrying the sheave could be run from the end of one cable direct to the other without delaying the work. The cable behind would then be carried forward and placed ahead of the one in use and so on continuously. These cables were found to carry the strain without danger and were especially advantageous for allowing ready movement forward or backward from one slab to the next. The deposit of the aggregate on the slope began at the top, which always gave a downward movement of the material. No attempt was made to give a finished surface other than that produced by a $2'' \times 4''$ scantling in evening up the aggregate to the required thickness after the necessary spade spreading. Before the final set occurs the top of the longitudinal joint is made, by a roller cutter, through the concrete down to the top of the lath (the lath being left in place).

The slope is paved in alternate panels; that is, if the panels should be numbered 1, 2, 3, 4, 5, 6, 7, etc., panels 1, 3, 5, 7, etc., would be completed and after sufficient set of the odd numbered panels, the forms are removed and placed ahead for a new section, leaving the finished panels to become the forming of the unfinished, even numbered panels. The mixing plant is then moved back and panels 2, 4, 6, etc., are completed, and so on until the completion of the work. (Fig. 5.)

About one-half of the work at Bates Island Bend was completed during the season of 1912, at which time it was not thought necessary to make provision for expansion joints, but during the hot weather of 1913, the necessity of expansion joints became evident when several of the slabs buckled up at the joints. In all cases where the slabs had buckled, which occurred at about 1,000-foot intervals, the joints were cut to let the slabs resume their natural position; because of this defect the remainder of the revetment was

Fig. 5. Concrete mixer and delivery plant; also completed section of paving.

provided with ½-inch expansion joints every 50 feet to allow the slabs to expand or contract lengthwise of the revetment.

Cost. As stated above no charge for plant depreciation has been entered into the cost of the revetment, but from the field cost as shown, a liberal percentage of cost of plant depreciation can be added and the total for this type will be under that of the standard type. The statement given below contains only field expenditures with the cost divided as follows:

	Per Lin. Ft.
Grading bank	$0.55
Weaving mattress	1.98
Concrete blocks in place	1.16
Ballasting mattress	1.13
Concrete paving	2.76
Total, per linear foot	$7.58

As 2 other pieces of this type of revetment have since been completed under similar conditions, their costs are given here for general comparison, and, to a certain extent, permit the establishment of a proper basis for estimates.

Marthasville Bend: 11.960 feet at $8.05 per linear foot, completed November 25, 1914.

The cost is divided as follows:

	Per Lin. Ft.
Grading bank	$0.84
Weaving mattress	1.85
Concrete blocks in place	1.56
Ballasting mattress	.83
Concrete paving	2.97
Total, per linear foot	$8.05

Dewey Bend: 7,215 feet at $8.13 per linear foot, completed December 17, 1915.

The cost is divided as follows:

	Per Lin. Ft.
Grading bank	$0.67
Weaving mattress	2.31
Concrete blocks in place	1.45
Ballasting mattress	1.22
Concrete paving	2.48
Total, per linear foot	$8.13

Failures. Before the work at Bates Island Bend was completed one break occurred where the paving was undermined, and the slabs broken in a diagonal line, down stream from the water surface to about 15 feet up the slope, over a length of about 100 feet. The exact cause of the break could not be determined, for, as nearly as could be ascertained by soundings the mattress and blocks seemed to be intact and later investigations confirm this fact. The break was located in a strong eddy (produced by a submerged false point which was not known to exist at time of construction), and the nature of the soil in the bank, fine sand, below the eddy was very unstable, which may account for the bank sliding or being sucked out between the interstices of the mattress. This break was successfully repaired with a brush and stone fill to fair out the bight and break up the eddy.

The revetment withstood the high stage of 1914, only to be battered and damaged during the continued high stages of 1915. This failure was described in the Annual Report of the Chief of Engineers, 1916, as follows: "This revetment (Bates Island Bend) was badly damaged at intervals, for a distance of about 6,000 feet

from the lower end; so far, a satisfactory reason for this damage has not been determined, as much of the paved bank with mattress and concrete blocks is intact at toe of slope, the breaks being mostly in the paving, 8 feet above the low-water line, where the slabs, with reinforcing strand and wire are broken in every conceivable manner and shape, the strand and wire being sheared off as though with a knife. At low water, about 1,000 feet of this revetment from the lower end, shows up with the bottom row of 8-foot paving slab intact, with a pocket of water 6 to 8 feet deep behind the line. The breaks in this revetment, except the 1,000 feet at lower end, were repaired with brush and stone fills to fair out the slope line, in all 2,956 linear feet."

Sufficient time has not elapsed to pass on the positive merits of the monolithic type, nor do the failures noted seem of such seriousness as to warrant its discontinuance, but from the many methods of slope paving and subaqueous bank protection still in the experimental stage, the problem seems to remain unsolved, and because of this, there will be no attempt made to forecast the values of any type of bank protection, as the number of unknown forces constantly in operation toward deterioration precludes any prediction of permanency.

Comments

By

Lieut. Col. J. F. McIndoe
Corps of Engineers

The standard revetment referred to by Mr. Haydon was developed under the Missouri River Commission. A modification thereof, consisting of paving the upper bank with concrete, was first used in this district in 1912. It has proved, on the whole, very satisfactory. More extensive use of concrete paving was prevented by the difficulties met in securing the gravel and sand, the only available supply coming from the Gasconade River, and therefore, this type has been constructed in only one bend each year, at points below the mouth of the Gasconade. Upstream towing of sand and gravel for anything but short distances would be prohibitive on account of cost, especially on the Missouri River, where rock can be cheaply secured from quarries within comparatively short distances from the banks to be revetted.

Mr. Haydon describes fully the details of construction, and the plant used. It should be stated that, beginning with the season of 1916, the wire mesh for reinforcing the concrete in upper bank paving was omitted as it was believed to be unnecessary. As the

units used by Mr. Haydon do not give a ready means of comparing the cost of the work, the cost per square (100 square feet) and the unit costs of materials for each square are given below.

Bates Island Bend. The cost, per square of the completed concrete paving of upper bank, was $6.59; and of subaqueous work, was $4.65, of which $2.31 was cost of mattress, $1.34 the cost of concrete blocks, and $1.00 the cost of ballast. The quantities and unit costs of materials for each square were approximately as follows:

Upper Bank Work—

Grading, 33 cubic yards at $.025 per cubic yard.

Concrete for paving, 1.24 cubic yards, at $4.52 per cubic yard.

Subaqueous Work—

Brush for mattress, .6 cord, at $1.59 per cord on barge.

Stone for ballast, .8 cubic yard, at $0.67 per cubic yard on barge.

Concrete blocks, 24 at $0.28 each.

Strand for mattress, 9.2 pounds, at $0.085 per pound.

Clips for mattress, .3 pound, at $0.06 per pound.

Marthasville Bend. The cost, per square of the completed upper bank paving, was $7.17; and of subaqueous work, was $4.86, of which $2.12 was cost of mattress, $1.79 the cost of concrete blocks, and $0.95 the cost of ballast.

The quantities and unit costs of materials for each square were approximately as follows:

Upper Bank Work—

Grading, 33 cubic yards at $0.046 per cubic yard.

Concrete for paving, 1.24 cubic yards at $4.57 per cubic yard.

Subaqueous Work—

Brush for mattress, .7 cord, at $1.58 per cord on barge.

Stone for ballast, .7 cubic yard, at $0.693 per cubic yard on barge.

Concrete blocks, 25 at $0.313 each.

Strand for mattress, 9.2 pounds, at $0.085 per pound.

Clips, .3 pound, at $0.06 per pound.

Dewey Bend. The cost, per square of completed upper bank paving, was $6.55; and of subaqueous work, was $5.80, of which $2.69 was cost of mattress, $1.69 the cost of concrete blocks, and $1.42 the cost of ballast.

The quantities and unit costs of materials *for each square* were approximately as follows:

Upper Bank Work—

Grading, 29 cubic yards at $0.048 per cubic yard.

Concrete for paving, 1.24 cubic yards at $4.08 per cubic yard.

Subaqueous Work—

Brush for mattress, .56 cord at $1.96 per cord on barge.

Stone for ballast, .86 cubic yard at $0.86 per cubic yard on barge.

Concrete blocks, 25 at $0.21 each.

Strand for mattress, 9.2 pounds at $0.085 per pound.

Clips for mattress, .3 pound at $0.06 per pound.

METHODS AND COST OF COFFERDAM CONSTRUCTION AT OREGON CITY LOCKS, WILLAMETTE RIVER, OREGON.

By

Mr. E. Burlem Thomson
Assistant Engineer; M. Am. Soc. C. E.

The locks at Willamette Falls in Clackamas County, Oregon, were built during the years 1870 to 1872 by the Willamette Falls Canal and Lock Company. The company was aided by the State of Oregon to the extent of $200,000 in gold bonds under provisions set forth in an "Act to appropriate funds for the construction of a steamboat canal at the Willamette Falls," approved October 21, 1870. The funds appropriated were contingent upon the locks being constructed on or before the 1st day of January, 1873. This and other provisions of the act were complied with and the locks completed and opened for traffic January 1, 1873. They have been maintained and operated continuously from that date to the present time. Ownership of the locks has passed through several hands, the Willamette Falls Canal and Lock Company selling to the Willamette Transportation and Locks Company, March 8, 1876, who in turn sold to the Portland General Electric Company, August 24, 1892. From the Portland General Electric Company possession was transferred December 31, 1907, to the Portland Railway, Light and Power Company, from whom the canal and locks were purchased by the United States April 26, 1915, at a cost of $375,000.

The falls are in the Willamette River near Oregon City, a small manufacturing town about 13 miles above Portland. The river at Oregon City spills over a horseshoe-shaped rocky reef of basaltic formation, the mean vertical distance between the water level above and below the falls being about 41 feet. Beginning at the northerly or downstream end, the canal and locks consist of a flight of four locks, each 210 feet long and 40 feet wide, having a lift of about 10¼ feet each, a canal basin above the fourth lock, 1,250 feet long, a guard lock at the upper end of the basin 210

feet long and 40 feet wide, and a bulkheaded approach at the southerly or upstream entrance 1,000 feet long, making a total length, including the locks and entrance, of about 3,500 feet. The location of the locks relative to Oregon City is shown on Plate I.

The original plans contemplated a depth of 3½ feet above the lowest lock sill at low water but changes in the plane of low water, due principally to improvements in the river below the locks, have reduced this clearance to about 2 feet at low water at the present time.

For further details reference is invited to the following Federal reports: House Document No. 202, Fifty-sixth Congress, first session; Annual Report of the Chief of Engineers, U. S. Army, for 1900, page 4374; House Document No. 99, Fifty-eighth Congress, third session; Annual Report of the Chief of Engineers, U. S. Army, for 1905, page 2497; House Document No. 1060, Sixty-second Congress, third session; Annual Report of the Chief of Engineers, U. S. Army, for 1915, pages 1524 and 3396; and other reports of the Chief of Engineers from 1900 up to date.

The project adopted by the Rivers and Harbors Act of June 25, 1910, provides for the purchase of the canal and locks, the rehabilitation of the same, and the separation of the ship canal from the water power intake, at an estimated cost of $600,000, of which amount $300,000 was to be contributed by the State of Oregon. This condition having been met by the State, and title to the property acquired by the United States, work on the improvement as outlined in the project was begun in May, 1915.

To make clear the necessity for separation of the ship canal from the waterpower intakes, it should be stated that some of these intakes are located along the east side of the canal and the suction caused thereby, when the plants are in operation, caused passing boats to draw towards the east side. Additionally, repairs to the canal and locks from time to time require the unwatering of the basin and suspension of operations by the power plants, involving loss of wages to several hundred workmen. The rehabilitation of the locks mentioned in the project consisted of the renewal of timber work and fenders, and the construction of 7 pairs of new wooden gates to replace those now in use.

From an engineering standpoint the principal feature of the work and the subject matter of this article is the methods used in the construction of the concrete division wall which, it was estimated, would cost in round numbers $142,000.

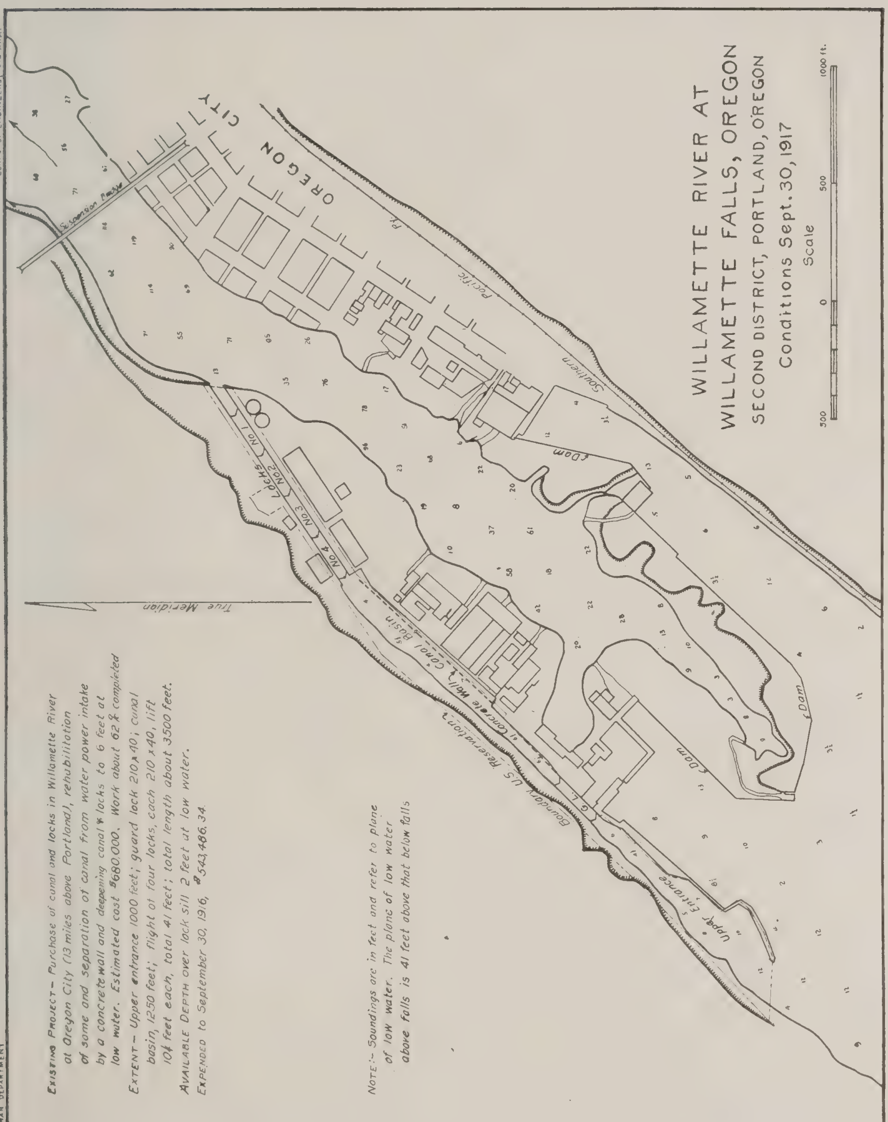
WILLAMETTE RIVER AT
WILLAMETTE FALLS, OREGON
SECOND DISTRICT, PORTLAND, OREGON
Conditions Sept. 30, 1917
Scale
CORPS OF ENGINEERS, U.S. ARMY
WAR DEPARTMENT
OREGON CITY
Suspension Bridge
Southern Pacific Ry.
True Meridian
Locks
No 1
No 2
No 3
No 4
Canal Basin
Concrete Wall
U.S. Reservation Boundary
Dam
Upper Entrance
EXISTING PROJECT – Purchase of canal and locks in Willamette River at Oregon City (13 miles above Portland), rehabilitation of same and separation of canal from water power intake by a concrete wall and deepening canal & locks to 6 feet at low water. Estimated cost $680,000. Work about 62% completed
EXTENT – Upper entrance 1000 feet; guard lock 210 x 40; canal basin, 1250 feet; flight of four locks, each 210 x 40, lift 10¼ feet each, total 41 feet; total length about 3500 feet.
AVAILABLE DEPTH over lock sill 2 feet at low water.
EXPENDED to September 30, 1916, $543,486.34.
NOTE:- Soundings are in feet and refer to plane of low water. The plane of low water above falls is 41 feet above that below falls

Plate I.

The terms in the deed transferring the canal and locks to the ownership of the United States provided that the canal and locks should be kept open to navigation so far as practicable without interruption, and that the United States should supply water by means of flumes to the various power plants during the construction of the wall.

The total length of the wall is about 1,250 feet, and that for convenience it is divided into sections A, B, and C with a cross wall, section F, between B and C. The wall decided upon was of gravity type, having a batter on either side of 3 on 1. The buttresses (spaced 10 feet on centers), are clearly illustrated on the isometric drawing of the forms used for the concrete, Plate No. II.

The first step was to remove from the bottom of the basin along the line of the proposed wall the accumulation of many years, consisting of old timbers, rock boulders, silt, and all kinds of junk. This work was done during May, June, July and August, 1915, by the U. S. dipper dredge *Champoeg*. The use of this dredge was practicable only along that part of the wall designated section C, and from this locality 8,094 cubic yards of broken rock at a cost of 57 cents per cubic yard, and 2,699 cubic yards of sand and other materials at a cost of 23 cents per cubic yard were removed. This is field cost, and includes placing the dredged material on barges and dumping in deep water above the falls. Steamboats passing daily through the narrow basin hindered the dredge and materially increased the cost of this work.

After various studies had been made of a suitable plant for the construction of the wall, it was decided to build the wall within a wooden coffer, and to deliver the concrete to the forms from a floating mixer which should obtain its supplies from storage bins erected on the west side of the canal.

The rock bottom precluding any of the usual forms of pile-driven coffers, a form of timber dam with a batter of 3 on 4, the face side covered with 18-ounce canvas, was adopted. The dam was constructed in sections 30 feet long, each section being floated into place and then sunk by filling the pockets provided for this purpose with gravel. These sections of dam were called *hurdles* during construction, and will be so alluded to in this article. A detail drawing of these hurdles is shown on Plate No. III.

The downward pressure of the water and the weight of the gravel were calculated to hold the dam in position, but additional

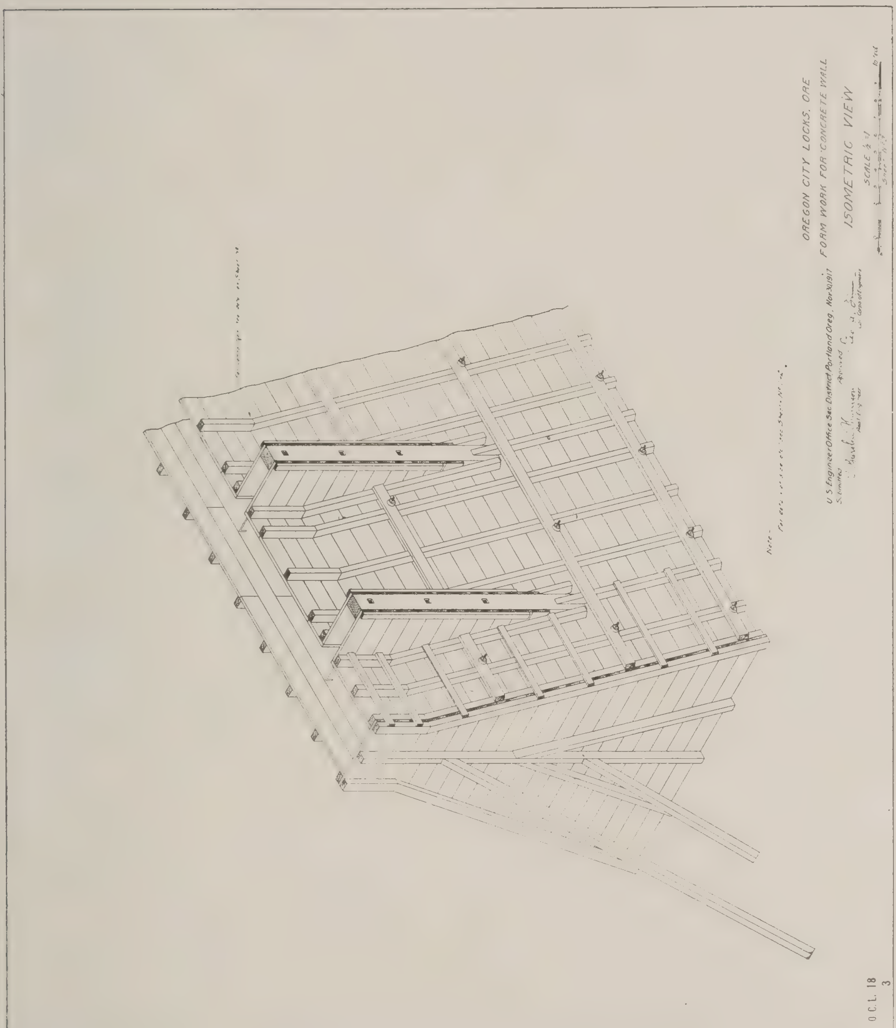
OREGON CITY LOCKS, ORE
FORM WORK FOR CONCRETE WALL
ISOMETRIC VIEW
O.C.L. 18
3

Plate II.

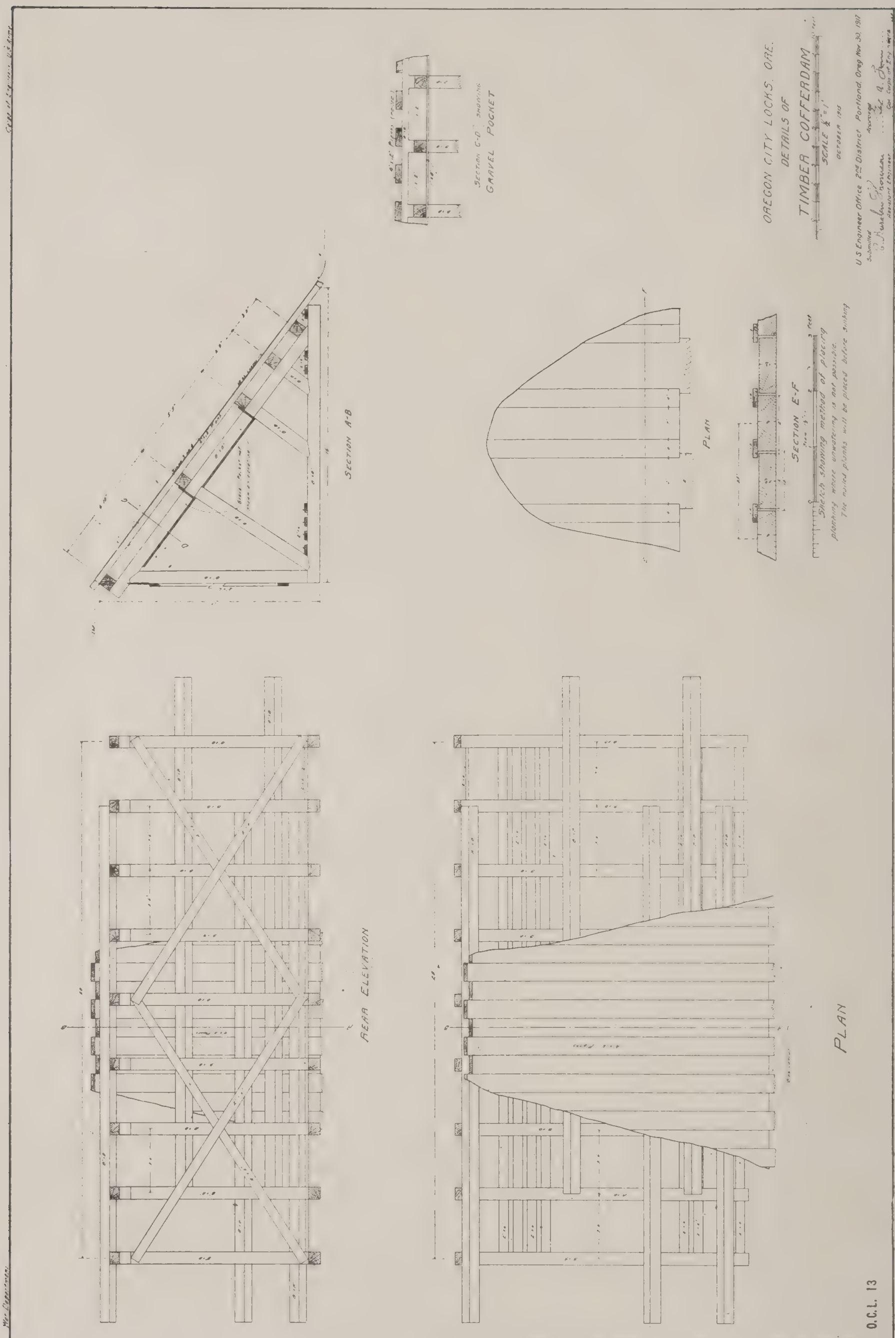
OREGON CITY LOCKS, ORE.
DETAILS OF
TIMBER COFFERDAM
SECTION A-B
GRAVEL POCKET
PLAN
SECTION E-F
REAR ELEVATION
PLAN
O.C.L. 13

Plate III.

bracing consisting of timber piling was placed inside to provide for possible thrusts due to vessels accidently striking the dam in passing. It was possible on certain Sundays to unwater the basin without serious interference with the power plants or navigation, and advantage was taken of this to adjust the dam to the contour of the bottom and to cover the face of the dam with canvas. It had been planned to attach chains along the lower side of the canvas sheets to cause them to sink, but, except in places where unwatering was not practicable, it was not necessary to use this device. Figure 1 shows the canvas being applied to the face of cofferdam

Fig. 1. Placing canvas on coffer No. 2.

No. 2, the basin having been unwatered. The grating seen in the foreground is the entrance to one of the wooden flumes built to supply water for manufacturing purposes during construction of the wall. One of these flumes is seen in the background of Fig. 2, weighted down with sacks of gravel to prevent disturbance if it should become necessary to flood the coffer.

The canvas covering was made up in sheets 51 by 30 feet with 4-inch lap double-sewed, and $\frac{5}{8}$-inch grommets spaced 15 inches all around the edge. Half-inch line was reeved through the grommet holes for convenience of handling. Each sheet was rolled, forming a convenient load of about 200 pounds for 4 men walking in single file. This was carried along the scaffold on the inside of the coffer

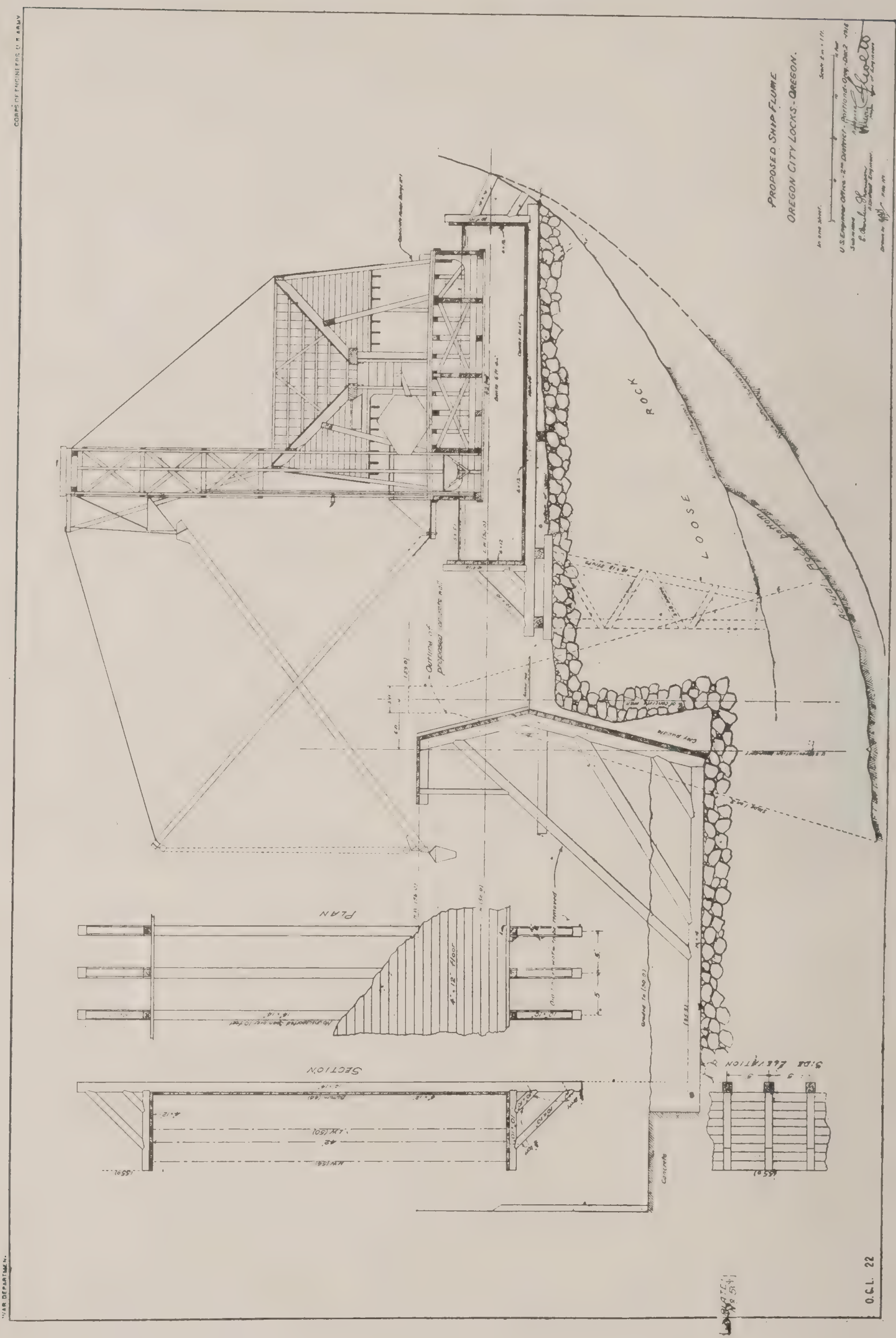
PROPOSED SHIP FLUME
OREGON CITY LOCKS - OREGON.
PLAN
SECTION
SIDE ELEVATION
LOOSE
ROCK
ACTUAL ROCK BOTTOM
Concrete
CORPS OF ENGINEERS, U.S. ARMY
WAR DEPARTMENT
O.C.L. 22

Plate IV.

and, being held at the top, unrolled by gravity into position. The bottom edge was weighted with superimposed sacks of gravel, and the vertical joints secured by wooden slats lightly nailed. At the south end of cofferdam No. 1, where the hurdles were impracticable on account of the irregularity of the cross section, and also at the southerly end of cofferdam No. 2, where lack of channel width prevented the less expensive hurdle, box coffers 8 feet square inside and 18 feet in height were used. These were floated into place and filled with gravel. The face of the boxes was covered with canvas spread at the bottom for a distance of about 6 feet over the rock

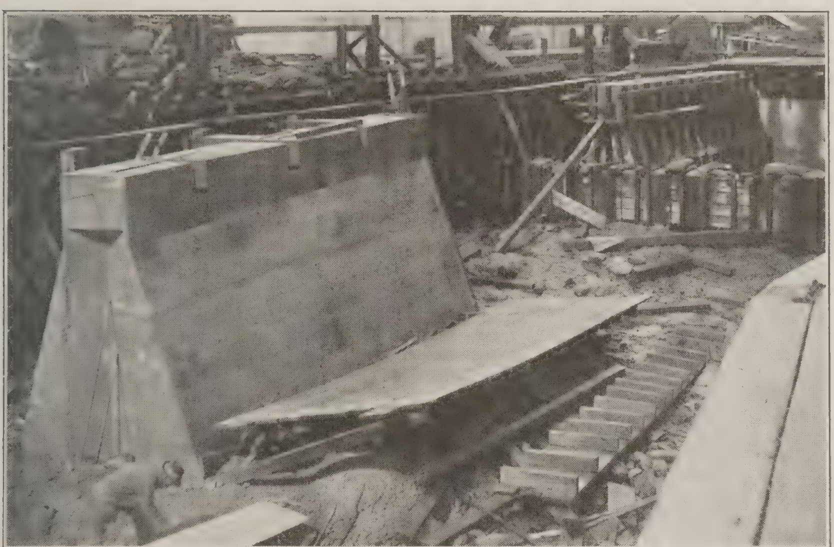

Fig. 2. Removal of forms, coffer No. 1.

surface and weighted with sacks of gravel. As a form of cofferdam for fairly even and impervious bottoms, the canvas-covered hurdles were found to be satisfactory and economical. They can be used several times and eventually taken to pieces without excessive cost, using the materials for other purposes.

Opposite section A, where the canal narrows to a width of 60 feet, there was not sufficient space to build a cofferdam similar to those used for the northern end of the wall, and it was decided to construct a large open aqueduct to carry the traffic during the time that was required to build this section of the division wall. The frames of the aqueduct were made with 14-inch square sills upon which were set 10 by 10 inch studs, well braced. These frames

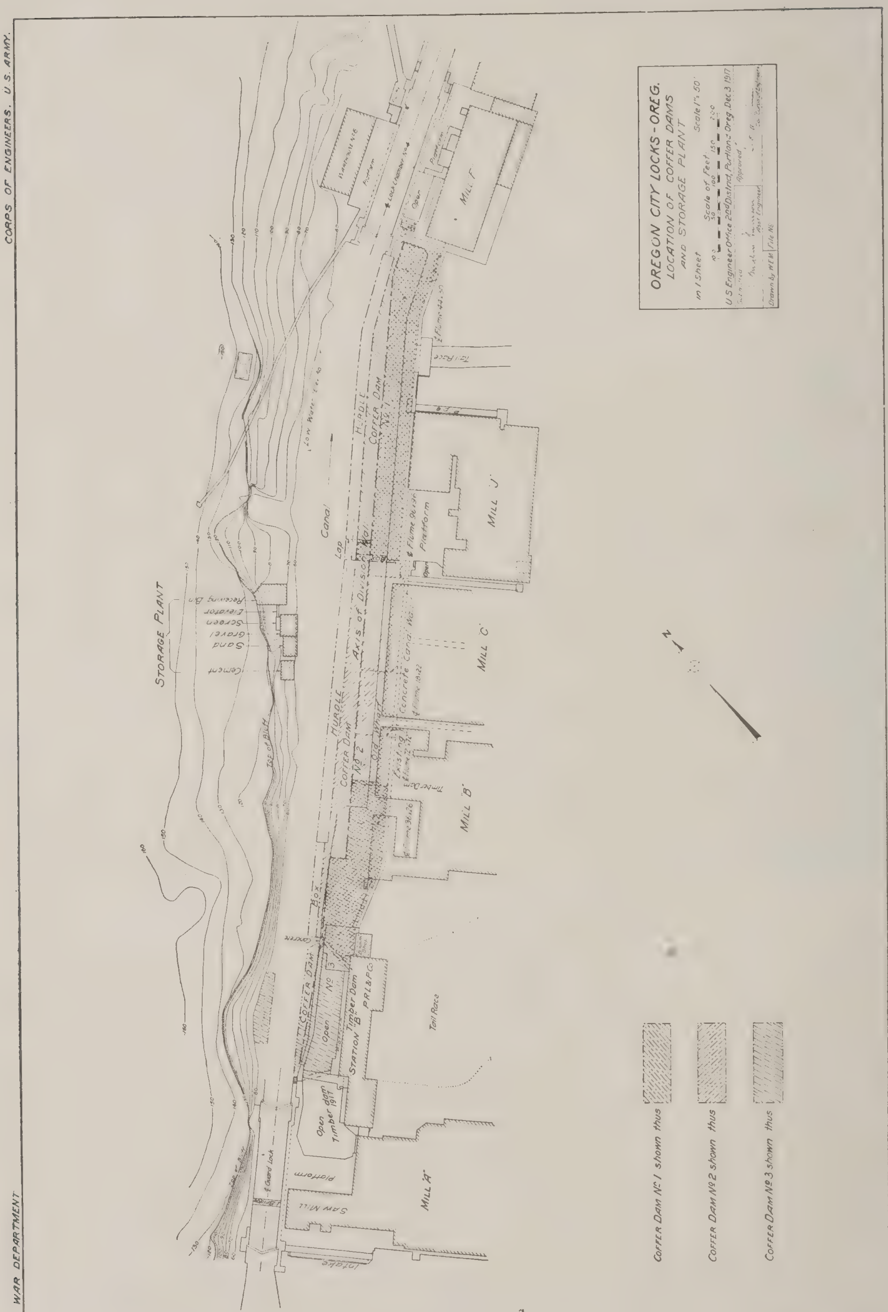
CORPS OF ENGINEERS. U.S. ARMY.
WAR DEPARTMENT
OREGON CITY LOCKS - OREG.
LOCATION OF COFFER DAMS
AND STORAGE PLANT
STORAGE PLANT
Cement
Sand
Gravel
Screen
Elevator
Canal
MILL F
MILL 'J'
MILL 'C'
MILL 'B'
MILL 'A'
Saw Mill
Platform
Intake
Tail Race
Coffer Dam No 1 shown thus
Coffer Dam No 2 shown thus
Coffer Dam No 3 shown thus

Plate V.

were set 6 feet on centers and the inside was lined with 4 by 12 inch planks covered throughout with heavy canvas. The finished inside dimensions of the aqueduct were 42 feet wide and 9 feet deep. Plate No. IV shows a sectional view of the aqueduct with the mixer barge floating in the completed structure. Figure 3 shows the aqueduct while under construction, Fig. 4 shows the canvas lining being placed, and Fig. 5, taken some two hours later, shows the first steamboat passing through. Traffic was maintained through this aqueduct for 5 months, and at no time was the leakage greater than could be cared for by two steam reciprocal pumps with a combined capacity of 450 gallons per minute. When the water had accumulated after Sunday or a holiday, it was removed by a 10-inch centrifugal pump, which was held in reserve in case of necessity.

Part of the work of excavating for the foundation of the wall (Fig. 6) was necessarily carried on beneath the aqueduct, which was heavily timbered as the excavation progressed. Figure 7 shows the aqueduct, looking north, and the bracing used to provide for any lateral stress caused by passing vessels. At a point near the southern end of the wall the excavation was carried 46 feet below the plane of low water, making the wall 55 feet high at this point with a base 33 feet wide. Rock bottom was reached at all parts of the wall before placing the concrete.

The general plan of the three cofferdams and location of storage plant is shown on Plate No. V. Advantage was taken of the existing concrete wall, built in 1894 by the Portland General Electric Company, and this in each case formed the easterly wall of the coffer. Four hundred and twenty-two linear feet of the concrete wall were built within cofferdam No. 1, and this completed portion of the wall was used to form part of cofferdam No. 2, the hurdles used in No. 1 being shifted and made to form the westerly wall of No. 2. The boxes which formed the southerly end of cofferdam No. 1 were also shifted and used a second time at the upper end of the westerly wall of No. 2. The south end of No. 2 was formed by an existing timber dam built by the Portland Railway, Light and Power Company.

The larger portion of the material above bedrock in the line of the proposed wall was removed by the U. S. dipper dredge *Champoeg*, and the remainder of the loose rock and other materials with a grab-bucket operated by U. S. derrick barge *No. 5*, and with the U. S. dredge and snagboat *Mathloma*, placed on flat scows and

dumped in deep water above the falls. The wall was built in alternate sections, each 30 feet in length, leaving 30-foot spaces between, which were filled in after the alternate sections were thoroughly set. The wall was calculated to resist the maximum hydrostatic pressure, assuming one side to be dry with the opposite side filled to the top of the wall. Any possible tendency to slide was taken care of by the irregularities in the rock surface supplemented by 4-foot lengths of 40-pound railroad iron sunk vertically and cemented 2 feet deep in the rock. From six to twelve of these were placed in each 30-foot section.

To protect the concrete buttresses which are spaced 10 feet on centers 8 by 12 inch timbers were used along section C of the wall. Upon completion of section C, 3 by 12 inch planks were nailed to these timbers horizontally, forming a continuous wooden wharf front from the deck to the low water line. The steel reinforcement consisted of a continuous ⅝-inch steel rod the entire length of section C, with vertical bent rods placed every 3 feet transversely. This was to provide for stress caused by boats striking the dock front. The isometric view (Plate II) shows the form in place ready for pouring concrete. Each form was used more than once. Figures 2 and 9 show a form partially knocked down, with the pieces ready to be picked up and placed in their new positions by the floating derrick.

The plant used consisted of a floating concrete mixer, a floating derrick, a floating pumping outfit, one deck scow 90 by 30 by 6 feet, two deck scows 16 by 40 by 4 feet and one 35-foot gasoline launch. In addition, the U. S. dipper dredge *Champoeg* worked from May to August, 1915, removing rock, etc., from the basin, and the U. S. dredge and snagboat *Mathloma* worked during parts of April, May, and June, 1916, and May 23 to June 30, 1917, supplying gravel, transferring cement from the railroad to the locks, towing, etc.

The general layout of the storage plant is shown on Plate No. V and on Fig. 8. On the right of the illustration is the receiving bin, with a capacity of 700 cubic yards. The scow carrying about 130 cubic yards, having been drawn up here, was unloaded by the derrick-scow with the grab-bucket, and the material placed in the receiving bin. From this bin the gravel was raised by an endless-belt bucket system to the screen at the back of the supply gravel bin, where all material larger than would pass through a ¼-inch mesh screen was deposited, the residue passing on through a wooden

Fig. 3. Aqueduct under construction, coffer No. 3.

Fig. 4. Aqueduct being canvassed.

flume to the sand supply bin beyond and adjoining. The capacity of the gravel supply bin was 386 cubic yards, and that of the sand supply bin 222 cubic yards. The elevator and screen were operated by a single cylinder 9 by 13 inch engine and 25-horsepower locomotive boiler installed underneath the gravel supply bin. The roofed-in building on the left of the illustration is the cement house, with a storage capacity of 2,400 sacks of cement. A platform which is hardly seen in the illustration receives the sacks of cement, which are wheeled by truck into the storehouse.

The floating concrete mixer was specially designed for this

Fig. 5. Aqueduct in operation.

work. The mixer is seen in operation in Fig. 9. The hull (90 by 30 by 6 feet) was built at a cost of $3,600, and the upper works at a cost of $2,550 by hired labor and Government plant. The machinery was purchased second-hand at a cost of $1,850, making a total cost of $8,000 for the plant. The gravel bin has a storage capacity of 57 cubic yards, and the sand bin 33 cubic yards. The space beneath the bins was floored and used for cement storage, the cement being also measured and delivered to the mixer from this floor. The concrete elevator was operated by a two-drum double cylinder 7 by 10 inch hoisting engine, and the mixer by a direct connected 8 by 10 inch double-cylinder engine. The boiler of the hoisting en-

gine supplied steam to both engines. The mixing outfit consisted of a 1-yard T. L. Smith mixer, a Ransome 22-cubic foot hoisting bucket, and a Ransome concrete chute with flexible end.

The materials were delivered by gravity into measured boxes, thence through chutes into the mixer. The gravel, sand, and water supplies were controlled by 1 man on deck, 2 men on the floor above supplying and measuring the cement. A concrete foreman watched

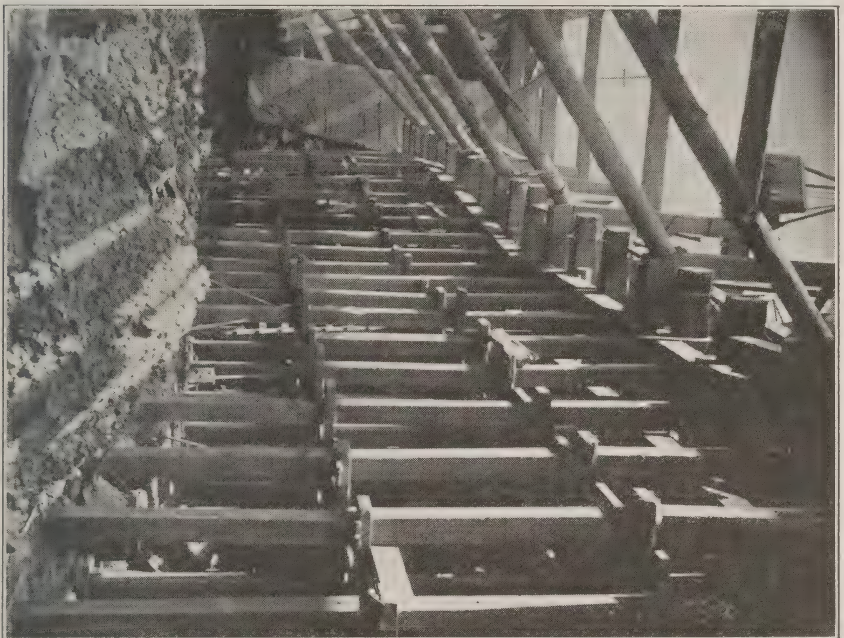

Fig. 6. Timber work under aqueduct.

and dumped the mixture, and 1 man aloft took care of the hoppers and the chute. The scow was handled by an engineman, a fireman and 2 deck hands, while an average crew of 7 men was required when delivering cement, sand, and gravel on the barge.

The mixer barge was in operation from May to October, 1916, and July to September, 1917 (about 8 months). During this time 9,175 cubic yards of concrete were mixed and placed in the wall at a field cost of $7,075.92, or about 77 cents per yard. Repairs for the period amounted to $135.50, or about 2 per cent of the field cost of operation. The total time worked was 1,745 hours, of which 126 hours, about 7 per cent, were chargeable to delays caused by moving

out for passing traffic. The remainder of the time was about equally divided between moving and loading and mixing and placing. The average performance was as follows:

	Cubic yards.
Concrete placed per hour	13.7
Concrete placed per day of 8 hours	109.6
	No.
Number of batches placed per hour	22
	Cubic yards.
Number of cubic yards per batch	0.62
Maximum 8-hour output of concrete	141.4

Dredging along the line of the proposed division was begun in June, 1915, and by the end of the following August 10,793 cubic yards had been removed from the canal basin, loaded on flat scows and dumped in deep water in the river about half a mile above the falls. The cost was as follows: 8,094 cubic yards of broken rock at 57 cents a yard, and 2,699 cubic yards of sand and gravel at 23 cents per yard. This price included loading on scows and dumping, the distance to the dump being about 3/4 of a mile.

Work on the construction of the storage bins began in October, 1915, and was completed in January, 1916. The cost for the three bins, one receiving bin, capacity 700 cubic yards, one gravel storage bin, capacity 386 cubic yards, and one sand storage bin, capacity 222 cubic yards, was $3,389.32.

Cofferdam No. 1 was begun in December, 1916, and completed in the following April at a cost of $8,400.44, or about $16.47 per linear foot, which includes construction and maintenance for five months. A total of 422 linear feet of the concrete division wall was built within this coffer.

Cofferdam No. 2 was begun in June, 1916, and finished by the end of the following month. The cost of this coffer, including four months maintenance, was $6,850.76, or about $11.61 per linear foot. Within this coffer section F (35 linear feet), section B (150 linear feet), and the remainder (478 linear feet) of section C were completed.

Cofferdam No. 3 was begun April 1, 1917, and finished April 25, 1917, at a cost of $4,133.10 or about $20.00 a linear foot, which includes maintenance for five months. Section A (185 linear feet), was built within this coffer. A wooden flume 500 feet long and 4 feet square in section was carried from the upper basin to supply the paper mills with power while the dam was

Fig. 7. Completed aqueduct, looking north.

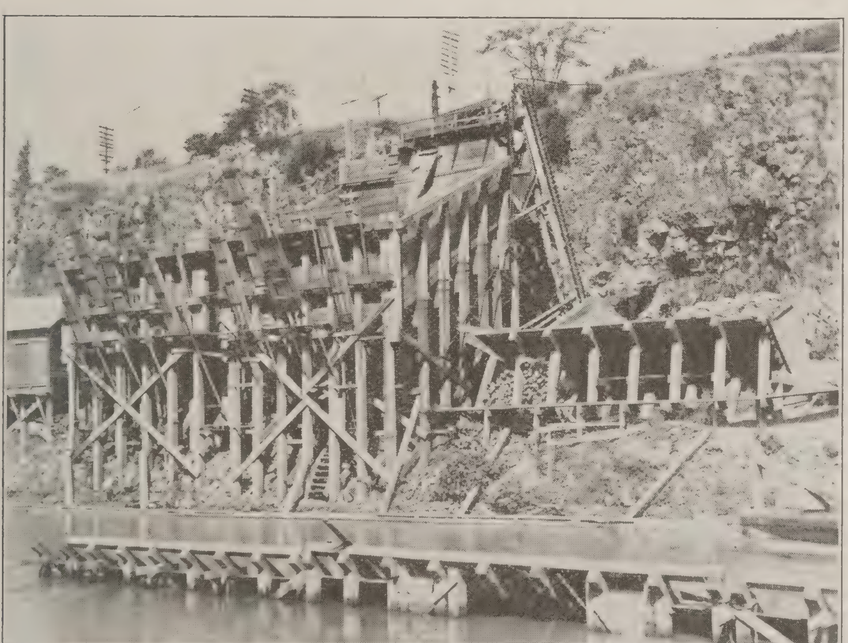

Fig. 8. Storage bins.

in course of construction. This was installed at a cost of $1,074.13.

In order to supply the mills with water during the construction of the cofferdams Nos. 1 and 2, box flumes, five in number, varying in size from 22 by 18 inches to 8 feet square were installed, the cost of these supply flumes is included in the cost of the cofferdams, and their position is shown on Plate No. V.

The cost of construction of the concrete division wall was as follows:

Dredging and excavating for foundations	$29,652.17
Plant and appliances	36,241.13
Cement	15,636.54
Sand and gravel	5,714.33
Formwork	5,278.14
Labor, mixing and placing concrete	7,040.41
Cofferdams	19,384.30
Local office and watchmen	10,679.02
Miscellaneous	11,385.02
Overhead	4,295.52
	145,306.58
Present value of plant used on work	12,305.00
Net cost	$133,001.58

Most of the plant used on the work is in good condition for further use.

The original estimate of cost made in 1912 was as follows:

14,000 cubic yards of concrete for dividing wall at $8.00 per cubic yard	$112,000.00
Timber platform for wall	3,200.00
Engineering and contingencies	26,265.00
Total	$141,465.00

In 1912 the Portland Railway, Light and Power Company offered to build the concrete wall for $150,000.

Portland cement for the construction of the concrete wall was purchased under contract at a cost of $1.40 per barrel free on board cars at Napa Junction, California. The freight was 7.562 cents, and the transfer from the railroad terminal to the site of the work 10 cents additional. The cement was delivered in sacks which remained the property of the contractor, the United States paying at the rate of 10 cents for each and every sack not returned in good order. About 95 per cent of the sacks were

Fig. 9. Mixer Barge No. 1 at work.

Fig. 10. Canal basin before improvement.

returned in good order and 3 per cent used in the work, taking the place of gunny sacks, the present market price of which is 15 to 16 cents second-hand. The cement was tested under the provisions of the United States specification for Portland cement, Department of Commerce Circular No. 33 of 1912, by a local laboratory and the cement found to be satisfactory in each and every test.

The proportions used in the concrete were 1:3:6 to 1:4:6, fluctuating with the varying percentage of voids in the aggregate.

The wall has been tested with a head of 8 feet of water on one side and dry on the other, but no sign of leak developed.

The aggregate was composed of sand and gravel obtained from the bed of the river within a 2-mile radius of the work, and delivered on flat scows at the receiving bin in the canal. The unloading was done by the floating derrick. Between January and June, 1916, and during June, 1917, 4,809 cubic yards of aggregate were dredged by the U. S. dredge and snagboat *Mathloma* at a cost of 40 cents a yard. The *Mathloma* being required for other work, 1,000 cubic yards of sand and gravel were obtained in competitive market at 40 cents a yard at the receiving bin. The requirements were that not less than 60 per cent of the material should pass through a ¼-inch mesh sieve and contain sand suitable for concrete having not more than 10 per cent silt. During the season of 1917, the use of the floating derrick was found to be practicable and the bulk of the sand and gravel used was supplied by this means at a cost of 28½ cents per cubic yard delivered at the receiving bin.

The construction of the concrete wall was begun May 15, 1915, and completed September 19, 1917. Between October 14, 1916, and April 2, 1917, work was suspended during the winter season in order to bring the time for constructing section A into the low water season when traffic is lighter. Not less than 10 per cent of the working period may be considered lost on account of the interruptions caused by the regular traffic through the locks.

Photograph (Fig. 10), taken before the concrete division wall was built, shows in the foreground the conditions before section A of the wall was constructed. Photograph (Fig 11) shows the face, and photograph (Fig. 12) the back of section A of the concrete wall after completion. Photograph (Fig. 10) was taken about 5 years ago. Figs. 11 and 12 were taken November 28, 1917.

Fig. 11. Face side of section A of concrete wall.

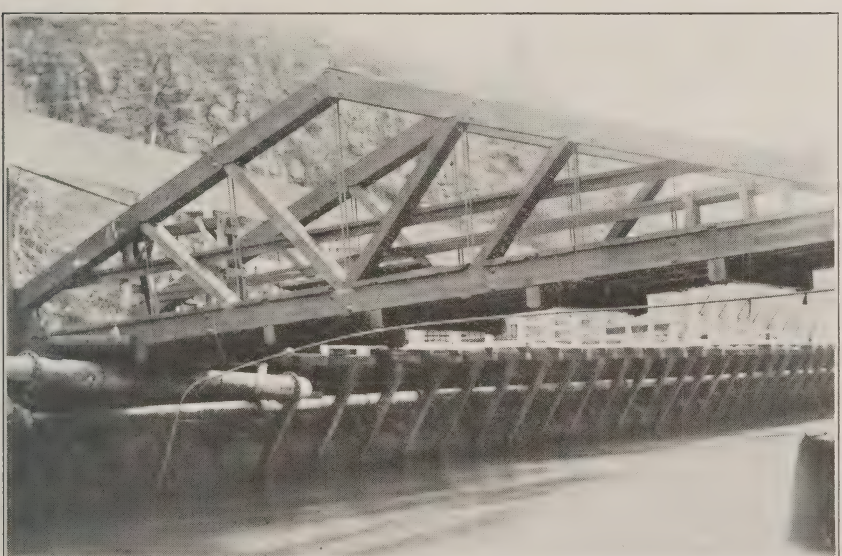

Fig. 12. Back side of section A of concrete wall.

JOHN GRUBB PARKE.

By

Lieut. P. C. Bullard.
Corps of Engineers.

John Grubb Parke was born near Coatesville, in Chester County, Pennsylvania, on September 22, 1827. His parents were Francis and Sarah Gardner Parke. When he was eight, his parents moved to Philadelphia, where, at thirteen, he entered Samuel Crawford's Preparatory School, and later, in 1843, the University of Pennsylvania. In 1845 he received an appointment to West Point, to the Military Academy, from which he was graduated in 1849, second in a class numbering forty-three, and was appointed Brevet Second Lieutenant in the Corps of Topographical Engineers. Up to the outbreak of the Civil War, he was engaged on surveys and explorations between the Mississippi River and the Pacific Ocean, locating railroads, state and national boundaries, etc., and on duties connected with river and harbor improvements.

In March, 1857, he was appointed Chief Astronomer and Surveyor for determining and making the boundary between the United States and the British Provinces, according to the treaty of 1846. On this service he was engaged until the outbreak of the Civil War, and again after its close until the completion of the work in 1869. He acquitted himself with credit in the performance of this duty, the work being one of great difficulty, as the line led through an almost unexplored country, crossing two mountain ranges. His first twelve years as an officer, previous to the Civil War, were thus passed in work well calculated to bring out the best qualities of a soldier, mentally and physically.

At the outbreak of the Civil War General Parke was a first lieutenant. In September, 1861, he was promoted to the grade of captain and on the consolidation of the two Corps of Engineers in 1863 he became a captain in the Corps of Engineers.

In November, 1861, he was appointed Brigadier General of Volunteers, and soon after reported to General Burnside, who

had been placed in command of the newly constituted Department of North Carolina. His force finally consisted of about 12,800 men, organized into four brigades under Generals Foster, Reno, Parke, and Williams.

On January 9th, 1862, they embarked from Annapolis, arrived soon after at Hatteras Inlet, and, after considerable difficulty in passing the entrance to the sound, started for Roanoke Island on February 5th; arriving the next day they promptly attacked, and two days later the enemy's line was carried. In this operation the terrain was such that the movements of the troops were of necessity left almost entirely to the direction of the brigadier commanders, who were highly commended by Burnside in his report. On the 14th of March, they stormed the defenses of New Berne and occupied the city. On the 25th of April they bombarded and captured Fort Macon. In his report, Burnside stated that the result proved that the work had been conducted by the right man. For his services here, Parke received the brevet of Lieutenant Colonel, U. S. Army. Soon after this, in July, he was raised to the rank of Major General of Volunteers.

In June, Burnside with the divisions of Parke and Reno, about 8,000 men, embarked for Virginia to reinforce McClellan. Going into camp at Newport News, he was joined by a detachment from South Carolina, and the whole was organized into the Ninth Corps. In August this corps was moved to Aquia, to hold the line of the Rappahannock, between Pope's army and Fredericksburg. Soon afterward General Burnside sent most of his troops to General Pope, retaining General Parke's division. From the middle until the end of August he was charged with despatching to their destination the troops arriving at Aquia from the Peninsula, General Parke acting as his Chief of Staff.

Early in September Burnside with his troops joined McClellan. During the campaigns which followed the former held various commands, retaining Parke as his Chief of Staff. Both took part in the battles of South Mountain and Antietam, in the pursuit of the enemy to Warrenton, and in the Rappahannock Campaign, including the battle of Fredericksburg.

On March 17, 1863, Parke was ordered to Newport News to command two divisions of the Ninth Corps, under Burnside, who then commanded the Department of the Ohio; with his command Parke went first to Cincinnati and then to Vicksburg.

There, until the end of the siege, he commanded on the line

from Hains Bluff to the Big Black River Bridge. Accompanying General Sherman on his Jackson expedition he commanded two divisions of the Ninth Corps and one of the Sixteenth. After the capture of Jackson, where his services brought him the brevet of Colonel in the regular army, Parke returned with the Ninth Corps to Vicksburg, and then to the Department of the Ohio.

General Parke's health had been so affected by the exposures of this campaign that he was obliged to take a sick leave for three weeks. On his return to duty he resumed command of the Ninth Corps and was ordered to move rapidly to reinforce General Burnside at Knoxville. He took part in the action at Blue Springs, and was chief of staff to Burnside in the defense of Knoxville. Upon the withdrawal of the Confederates, Parke moved in pursuit with the Ninth and Twenty-third Corps. After a few days both armies went into winter quarters. For his services in the siege he was brevetted Brigadier General.

In March, 1864, Parke was sent with the Ninth Corps to Annapolis, Burnside assuming command. Recruited to 21,000 men and reorganized into four divisions under Generals Crittenden, Parke, Willcox, and Ferrero, the corps moved to the support of the Army of the Potomac. It first constituted a separate army under the direct command of General Grant, and later was assigned to the Army of the Potomac. With his division, Parke was engaged in the Battle of the Wilderness, and in the battles around Spottsylvania. His health then obliged him to take another short sick leave. On his return he was appointed Chief of Staff of the Ninth Corps. After taking part in the passage of the James River and the march on Petersburg, he was again compelled by malarial fever to be absent on sick leave for a month and a half.

He then commanded the Ninth Corps until the close of the war, taking part in the siege of Petersburg from August, 1864, until April, 1865. Twice for short periods he commanded the Army of the Potomac in the absence of General Meade. In August, he coöperated with the Fifth Corps in the seizure of the Weldon Railroad.

His corps was reorganized in September and, after several later changes, at the end of the year it consisted of 30,000 men. The Ninth Corps was engaged, September 29-October 1, at Poplar Spring Church and Peebles Farm, occupying the extreme left of the Union line. Another action was fought in part by this corps

at Hatchers Run. On November 29th it was transferred to the right of the Union line.

At dawn, on March 25th, 1865, the Confederates under Gordon assaulted and captured Fort Steadman, but the fire of Parke's troops soon drove them out. For this repulse, Parke was breveted as Major General.

On March 24, in the general order of attack, Grant had designated Parke to command the force left to hold the lines of Petersburg and City Point, with instructions to attack if the enemy's lines showed signs of weakness. At 4:30 A. M. on April 2nd, Parke made a vigorous assault on the front of Fort Sedgwick, carried the front line, reversed the parapets, and served the Confederate guns against their owners. Counter-attacks failed to dislodge him, and in the night the enemy abandoned the city to the Union troops. Leaving General Willcox to hold the city, Parke pushed on with the remainder of his troops and joined in the pursuit of Lee until the latter's surrender on the 9th.

With his Corps he then returned to Washington, and for three months commanded the District of Alexandria. He then commanded the Southern District of New York until January 15, 1866, when he was mustered out of the volunteer service, and returned to duty as major of engineers. From 1866-69, he was engaged with fortification work and river and harbor improvement, in addition to finishing his work on the Northwest Boundary. From June, 1868, until August, 1887, he served as major, lieutenant colonel, and colonel in the position of assistant in the office of the Chief of Engineers. Here his wide experience made him particularly valuable. From 1887 to 1889 he was superintendent of the U. S. Military Academy. On July 2d, after forty years service his name was placed on the retired list.

In June, 1867, General Parke married Ellen Blight, of Philadelphia. On his retirement, he made his home in Washington. He was actively engaged as director of banks, etc., during the remainder of his life. In 1889 he was elected president of the Society of the Army of the Potomac. He died at Washington, December 16, 1900, at the age of seventy-three. He had served throughout almost the entire Civil War as General Officer, and had won four brevets for gallant and meritorious services. Such in brief was the career of an officer clear-headed, modest, loyal and just, and beloved by all about him.

SAPPING OPERATIONS, ESPECIALLY FOR INFANTRY: FROM A LECTURE TO CADETS AT SAINT MAIXANT, FRANCE.[1]

By

Capt. A. Gay,
French Army.

Ditches employed in field fortification for firing or for communicating under shelter have properly two distinct names, according to the manner in which they are made. Excavations made by sappers advancing step by step are called "saps," and the name "trench" is reserved for excavations dug simultaneously along a line of greater or less length.

In ordinary language it is customary to call a firing trench a "trench"; a communication dug parallel to the front, a "parallel"; and a communication dug perpendicular to the front, a "boyau."

The words sap and trench, nevertheless, retain their meaning to indicate the method of work which is employed; for example, one might say with great accuracy a "boyau built as a trench," or a "boyau built as a sap," or a firing trench built as a sap, etc.

Among the excavations dug as a sap are distinguished:

(a) The sap of rolling earth, which is now called a boyau.

(b) The flying sap of gabions, of sand bags, or of gabions and sand bags, which involves no digging, and of which the two parapets are made by two rows of gabions, of sand bags, or of gabions and sand bags 1.80 to 2.00 m. in height.

(c) *The Deep Sap.* First the deep sap not covered, which is a boyau without parapets, the earth having been thrown out to the rear as the digging progresses. Second, the deep covered sap or covered sap, which is the former concealed by a light layer of earth supported by wattles or logs. Third, a blinded sap or covered sap, of which the wooden roof is proof against balls and splinters. Fourth, the Russian sap, a subterranean gallery without sheeting, of which the roof is made in the form of an arch at 0.25 or 0.30 m. below the level of the ground. Hereafter the work of sapping is described in the minutest details of its execution. The first oper-

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[1]Translated by Col. W. R. Livermore, U. S. Army.

ation, which is called the *debouch*, consists in opening a sap-head through the parapet of the trench of departure. The debouch from the trench, obtained by one of the methods explained hereafter, is first made 0.40 m. in front of the head mask by shields or by sand bags in close contact with each other.

SAPS OF ROLLING EARTH.

So called because the workmen at the head are protected by a mask formed by a bank of earth, which they shove along by means of a sweep as they progress. In certain cases it may be advantageous to employ as a mask a long gabion, or a pipe of reinforced cement filled with earth or broken stones, or sand bags, or a shield of steel, etc.

The Single Sap is employed in the immediate vicinity of the enemy (Fig. 1).

Personnel. Each sap-head detachment is composed of 1 sergeant, and 4 sapper pioneers. The detachment is divided into 2 equal squads, which relieve each other at every meter and work in the sap or rest in the trench alternately. Continuous day and night work requires, 1 sergeant, 1 assistant, and 12 men in 3 reliefs of 4 men, relieving each other every 8 hours.

If the effective strength permits, one man is attached to each sap-head as a supernumerary. In the working squad, the sappers are numbered 1 and 2. At each relief, they change posts; No. 1 becoming No. 2, and conversely. Sapper No. 1 is furnished with a pick and a sweep with a short handle, and also a 1-meter measure (the upper width of the sap) and a 2-meter measure (the depth of the sap). Sapper No. 2 is furnished with an ordinary shovel and has also a measure of 0.30 m. (breadth of the berm).

Matériel. The sap-head should be provided with the following materials:

A wooden sweep with a long handle.
An ordinary iron hoe with a long handle.
A packet of small pickets,
A pick and 2 spare shovels,
A shovel with a short handle, or a spade-shovel,
A hurdle and a metallic lattice to form a splinter-proof.
A supply of hand grenades.

Execution of the Sap. The sergeant, chief of the sap-head, indicates with pickets the direction of the sap, and with pickets and a 1-meter rule the task of the relief, places his 4 sappers, and fre-

quently verifies the dimensions at each stage and notes the time taken by each relief to complete its task. Sapper No. 1 (a picker) works from the front at the head of the sap. At first kneeling or stooping, he digs the earth for the width and depth of the sap, 1 m. at the top and 0.80 m. at the bottom, 2 m. in depth below the natural level of the ground. He makes, at first, 2 furrows of the depth of the iron part of the pick so as to undercut the block to be detached. He breaks down the part thus undercut and commencing below, shoves the earth between his legs by the aid of a sweep with a short handle (or a spade-pick), taking pains to clean the sap so as to maintain the full depth of 2 m. Then, standing up, he attacks the upper part of the excavation, making the grooves equally on the right and left, up to the natural surface of the ground; then he throws down with his pick the mass thus undercut and marked off for him, and passes the earth between his legs as above. He thus advances by stages of about 0.40 to 0.50 m., verifying the dimensions from time to time by means of the measures with which he is supplied. Sapper No. 2 (a shoveler) keeps behind No. 1. He raises the earth scraped by sapper No. 1, at first with a short-handled shovel or shovel-spade, then with an ordinary shovel, throws it in front to thicken the mask, and then to the right and to the left to form the parapets. The earth thrown out by sapper No. 2 passes over the head of sapper No. 1, or to his right or left . . . He is careful so to spread the earth over the most advanced part of the parapet as to stop the gap which is formed after the advance of the head mask, and over the mask itself so as to maintain its normal dimensions. He makes a berm of 0.30 m. between the parapet and the edge of the excavation. Sappers No. 1 and No. 2 can change places toward the middle of their fixed task at an advance of 1 m.

Advance of the Mask. When the digging has reached the mask, sappers No. 1 and No. 2, aided if needed by the other squad, stooping as much as possible to avoid being discovered, shove the head mask about 0.40 to 0.50 m. forward, pushing up the earth by the aid of the sweep, or by throwing sand bags on the forward part of the mask. Sapper No. 1 backs up against the head of the sap, puts the sweep against the mask, pulls down on the handle, and all the sappers together shove the mask forward.

Change of the Workmen. At the signal, "change," made by the head sapper when the new digging has reached the length of his

rule, 1 m. long, the first squad lays down its tools and is replaced by the second.

Speed of Advance. 1 m. to 1.30 m. an hour.

DOUBLE SAP.

A process employed in very close proximity to the enemy so as to advance at double speed (Fig. 2).

Personnel. Each sap-head requires 1 sergeant and 8 pioneers, divided into two reliefs. Continued work requires 1 sergeant, 1 assistant and 24 men in three reliefs of 8 men, relieving each other every 8 hours.

In each relief these pioneers are numbered from 1 to 4, numbers 1 and 3 being pickers, and numbers 2 and 4 shovelers. No. 1 is furnished with a 1-meter rule; No. 3 with rules of 1 m., 2 m., and 0.30 m.

Matériel. The same as for the construction of the sap by one stage, taking account of the double number of workmen.

Execution of the Sap. The pioneers 1 and 2 (Fig. 2) with short-handled tools work at the head of the sap and first excavate a stage 1 m. wide at the top, and 0.90 m. at the bottom, and 1 m. deep below the surface of the ground. (Fig. 3.)

The pioneers 3 and 4 (Fig. 2) with ordinary shovels and picks, keep always within 3 m. of the head of the work. They deepen the first stage to 2 m., and throw the earth, spreading it tangentially to the upper contour of the parapet of the head stage, so as to increase in width this parapet opposite their stage; with the sweep they push up the earth over the parapet, so as to make a regular berm 0.30 m. wide (Fig. 4).

Advance of the Mask. As for the single sap.
Change of Workmen. Every meter they advance.
Rapidity of Advance. Rapidity double that of the single sap.

SAPS OF GABIONS OF SAND BAGS AND OF GABIONS AND SAND BAGS.

When the ground on which one, in advancing, cannot be removed to a sufficient depth, the parapet is made in whole or in part with gabions, with sand bags, or with gabions and sand bags. The work can either begin at once along the line, or advance step by step. In the latter case sand bags alone are used.

Flying Sap With Gabions.

Two groups of workmen: The first group puts the gabions in place, in the direction determined beforehand. The second group fills them.

If sap is entirely in relief the filling is done by sand bags half filled or two-thirds filled at the most. The first parapet being so formed, is given the height and thickness required by doubling and trebling the rows of gabions, while doubling their height.

If the nature of the soil permits, a trench is dug at the foot of the line of gabions, leaving a berm of 0.30 m. to 0.40 m. The gabions are then filled with the earth from excavation (Fig. 5).

Flying Sap With Sand Bags.

In Ordinary Work—all along the line (night work) the parapet comprises: First, three adjoining rows of, say, 10 bags superposed; above it two rows of 4 bags to form crowning of from 0.80 m. to 1.00 m. (Fig. 6) in thickness at the top; third, eventually, if space permits, three rows of sacks, to make banquette for firing. On top two rows of bags to form an elbow-rest.

NOTE.—The dimensions of the figure are approximate, and based on the official dimensions for sand bags.

Empty sand bags, 0.66 m. long; 0.33 m. wide.

Filled sand bags. (*a*) standing: 0.50 m. high and 0.22 m. in diameter; (*b*) lying, 0.18 m. thick and 0.25 m. wide.

The sand bags are placed to break joints; the rows are formed successively in order of the numbers on Fig. 7. In course of construction the heads of the different rows so overlap as to permit of the simultaneous advance on these rows.

The total height of the cover is 1.80 to 2.00 m. It requires 150 sand bags to each running meter. The rapidity of advance can be as high as 15 to 20 meters an hour.

In Advance, Step by Step. The preceding sap can be made step by step (day work) by carriers, passers and placers.

This method of work is clearly shown by Fig. 8. The men charged with placing the bags at the head, or placers, are sheltered behind that part of the work already made, receive the sand bags from a line of passers, themselves supplied by helpers (carriers).

Flying Sap of Gabions and Sand Bags.

Whether it is made all at once, or step by step, the flying sap of gabions and sand bags will be constructed according to the principles explained. The rows of gabions are doubled or trebled, and are

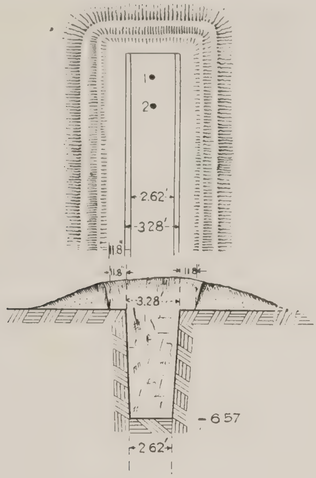


Fig. 1. Execution of the single sap.

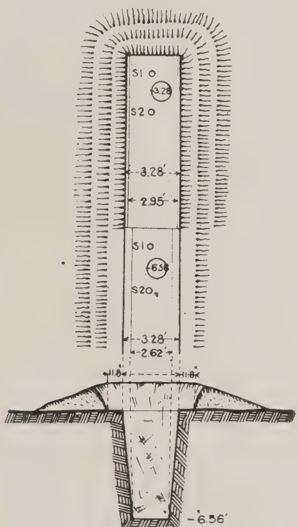


Fig. 2. The double sap.

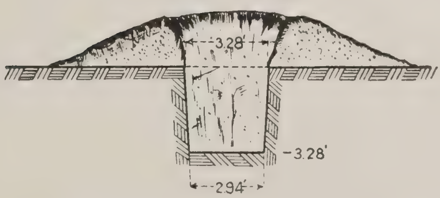


Fig. 3. Double sap (first stage 1 m. deep).

surmounted by many courses of sand bags (Figs. 9 and 10). On the other hand, the piles of sand bags may be doubled or trebled while only setting up a single row of gabions. (Fig. 11.)

On account of its slight visibility, the deep sap not covered is employed to advance over ground especially dangerous by the enemy's fire, but easy to excavate. (Fig. 12.)

The personnel, the matériel and the process of execution are precisely the same as those described above for the single or double sap of rolling earth.

The earth is thrown out to the rear by helpers, relays of shovelers (4 m. to a relay), by baskets or wheel barrows (30 m. for a relay of wheelbarrows) or by wagonettes on a track of 0.40 m. gauge. The enemy finds it hard to regulate his fire on the sap-head, which only becomes visible at a distance of 30 to 40 meters.

Garages. Make turn-outs, along the way: I m. in length and 0.60 m. in depth.

Back Steps. To provide for the rapid evacuation of the sap in case of need, steps to the rear are built every ten (10) meters at the most, as shown in Fig. 13. These steps are 0.45 m. in height and 0.50 m. in breadth and in depth.

Deep Covered Sap—Blinded Sap—Russian Sap.

Lest the enemy should discover by his aerial observations the exact position of the approaches, it may be advisable in certain cases to cover them.

Deep Covered Sap.

If the ground is hard enough, place along the edges of the excavation a course of logs bearing transverse logs at every meter; support on them a roof of logs or fascines covered with a light layer of earth which matches the natural soil (Fig. 14).

If the ground is not so good, support the roof on frameworks improvised of logs. (Fig. 15.)

Blinded Sap.

A covered sap, the roof of which is proof against balls and splinters of artillery projectiles. The roof is supported by wooden frames, called blindage frames, which are placed laterally against the walls of the approach. (Fig. 16.) The frames are composed of two uprights, a sill and a cap, mortised and tenoned if the wood is square, or by means of scarfing and spiking if the wood has the bark on it.

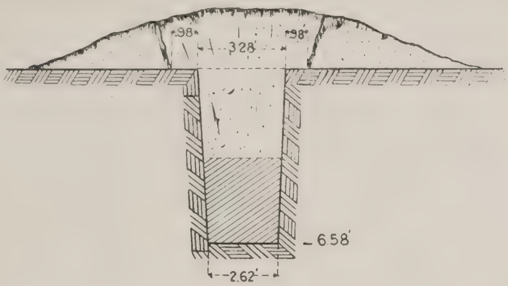


Fig. 4. Double sap (second stage 2 m. deep, and execution of the berm).

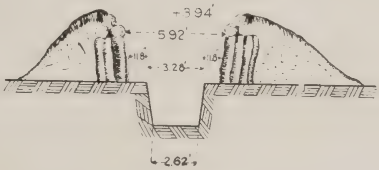


Fig. 5. Flying sap with gabions.

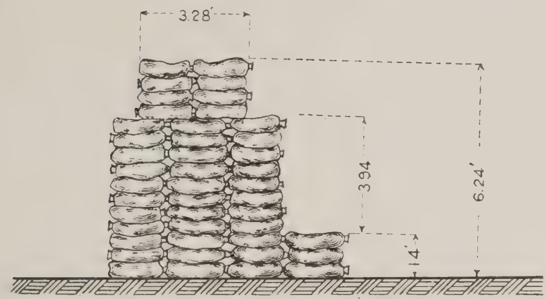


Fig. 6. Parapet of sand bags (cross section).

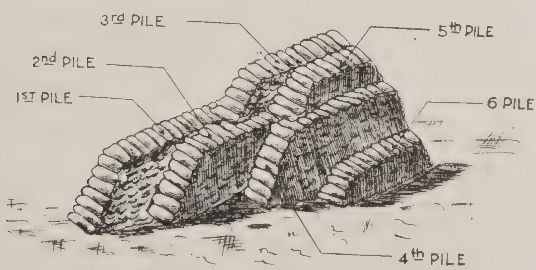


Fig. 7. Parapet of sand bags (perspective).

Every blindage frame is placed in a groove 0.20 m. wide, dug while advancing in the plane of the slope in which the digging is to be made. Two frames facing each other are connected by two beams, held with cleats or nailed to the cap sill to keep them at the same distance apart (Fig. 17). The roof is made by planks (0.04 to 0.05 m. in thickness) or logs placed above the beams and surmounted by a row of fascines which are put in place by aid of sap hooks (Fig. 18). The digging is made under the shelter of this mask and the excavations are thrown over the fascines; if necessary, the lateral walls are revetted by planks, small logs or wattles engaged between the uprights of the blindage frames and the slopes of the digging.

Blindages are small portions of blinded sap whose principal object is to withdraw from enfilade fire certain parts of the communications. They can be executed (as will be indicated) or more simply by arranging on the beams of the sap (Fig. 19) two courses of logs, planks or fascines, on which beams, logs or rails are placed crosswise side by side. The hole is covered by a bed of branches or fascines and then of earth up to the upper level of the parapet.

Personnel and Tools. Each covered or blinded sap-head detachment is composed: first of 8 sappers directed by a sergeant, the chief of sap, and divided into two equal squads, to relieve each other from meter to meter; second, of a sufficient number of auxiliaries to transport the earth. In the squad which is working, sappers 1 and 2 are each furnished with a pick with a long handle and with a sweep with a short handle, and have besides a 2 m. measure (depth of the sap), and a 1 m. measure (width of the sap), and length of the task of each squad). Sappers 3 and 4 are each furnished with an ordinary shovel and have also a sweep with a long handle; the helpers are supplied with the following method adopted for the evacuation of the ground.

Execution. Sappers 1 and 2 work alternately at the head of the sap and relieve each other as often as necessary. They dig in the natural ground under and in the direction of the blindage. The head sapper at first makes grooves on the right and on the left along all the top of the stage; then a groove in the lower part; when the natural earth falls in he passes it behind him by pushing it between his legs with the sweep. He takes good care to clean his stage well in order to preserve its full depth. Sappers 3 and 4 immediately behind the head sapper rapidly draw the earth towards them with a long-handled sweep. According to the mode of evacuation em-

Fig. 8. Construction of a sap with sand bags (advancing step by step).

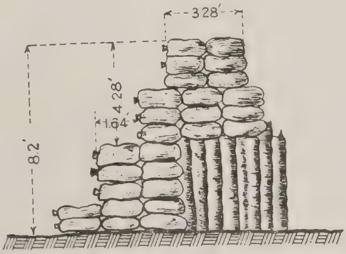


Fig. 9. Two rows of gabions.

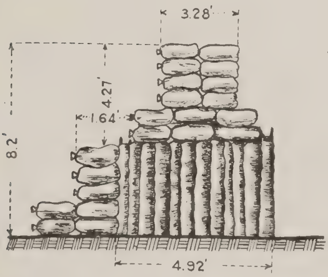


Fig. 10. Three rows of gabions.

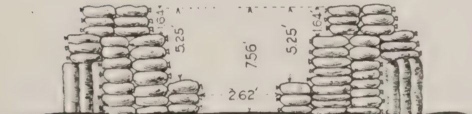


Fig. 11. Trench with gabions and sand bags.

ployed they throw the earth to a relay of shovelers or put it in the boxes, baskets, barrows, cars and wagonettes which the helpers bring to them. The task of each squad, which is 1 m. long, is measured by starting from a picket, planted by the chief of sap as soon as the squad arrives at the left wall of the sap. Every time that the sappers of the squad change posts, 1 and 2 become 3 and 4 reciprocally. The direction of the sap is marked by pickets planted in the rear at the bottom of the trench, and at two points where they will not interfere with the removal of the earth.

Russian Sap. In consistent soil a gallery can be made without sheeting and with the intrados in the shape of an ogive (Fig. 20). This is the perfection of the deep sap as to the invisibility which it requires. It is chiefly employed for the establishment of the parallels of assault and of the branches which should lead to them. It is then made 0.25 m. or 0.30 m. below the level of the ground; if made of a greater depth it comes within the category of unsheeted mining galleries.

Bored Sap. The bored sap is made by the explosion of an allongated charge of powder, of melinite or of cheddite, placed by means of a boring parallel to the surface of the ground and at some depth. It is employed to pass for a short distance through ground particularly hard to excavate; a ballasted road for example.

Outlet From the Trench to the Sap.

After having marked by picket the point of intersection of the new sap with the trench, we advance by the square across the parapet by the step by step sap. The earth forming the parapet of the trench serves as a head mask during the passage of the parapet, and all the excavated earth should be thrown obliquely forward to form new parapets. As soon as the old parapet no longer covers the sap head sufficiently, part of the earth is thrown forward to form the new mask, behind which the sap head then resumes its regular progress and is so inclined as to advance in the new direction to the sortie from the parapet.

Debouch with a Covered or Blinded Sap. The uncovered outlet has the objection that it reveals to the enemy the point of *debouch* and when this point is near the enemy makes it the constant objective for his grenades. The *debouch* under a blindage is employed at the moment when the trench is digging. The location of the debouches can be fixed. It is then sufficient to dispose in advance at the proper place on the ground the materials of

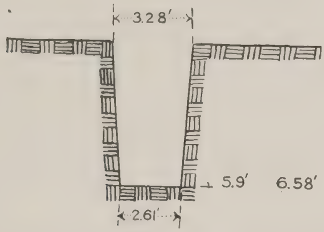


Fig. 12. Deep sap, not covered.

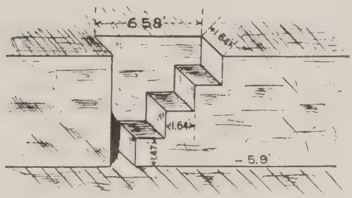


Fig. 13. Back steps.

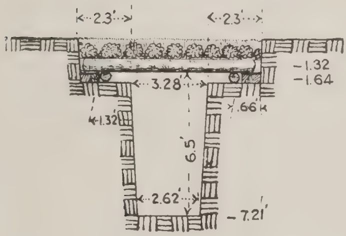


Fig. 14. Deep sap, covered.

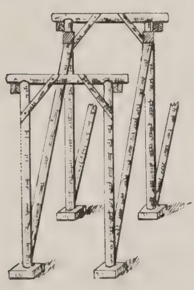


Fig. 15.

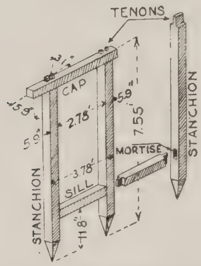


Fig. 16. Blindage frame.

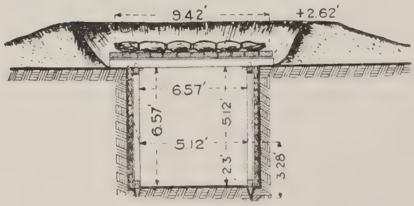


Fig. 17. Blinded sap (transverse section).

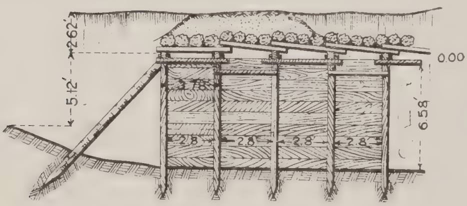


Fig. 18. Blinded sap (longitudinal section).

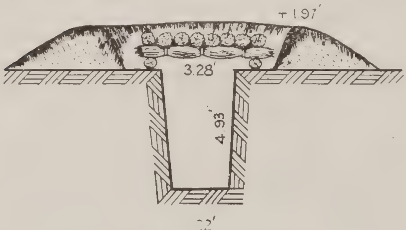


Fig. 19. A blindage.

the blindage (planks, logs, railroad ties, etc.), under which the sap passes. The planks of the blindage are at least 1.60 m. in width. They are brought up and put in place by a special squad of workmen and are arranged on the ground at the moment the workmen are placed in the trench. These materials are disposed flat upon the ground at night, perpendicularly to the trench and

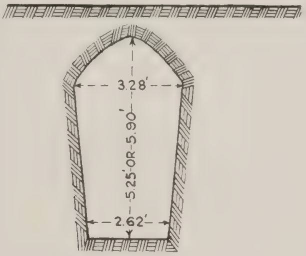


Fig. 20. Russian Sap.

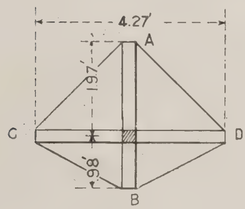


Fig. 21. Device to prevent the explosion of grenades (transverse section).

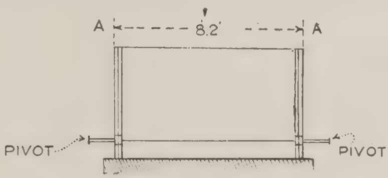


Fig. 22. Device to prevent the explosion of grenades (longitudinal section).

end for end. They are immediately covered with earth to conceal them from the enemy.

Disposition for Protection Against the Explosion of Grenades. When the saps approach the enemy's trenches the workmen should be protected against the explosions of the hand and rifle grenades. It is easy to make a protection against percussion weapons, by a surface of impact that will slowly check the projectile by yielding under the shock.

Two wooden crosses, AB, CD are made. The extremities ABCD are connected by a strong wire. At the center is a large nail or anything that can serve as a pivot (Fig. 21). The two quadrilaterals thus obtained are connected by a plank BD (Fig. 22), the extremities AA, CC, DD, by a large wire. This forms the frame work of the apparatus. It will be completed by covering this skeleton with a metallic lattice (Fig. 23). When completed, the grenade screen is placed over the sap, either on traverses which support the two pivots, or by some other method. It is balanced by means of a sandbag placed across the connecting pin. By throwing the earth to the right or left, CD is easily made horizontal. Experience has proved that this device is efficacious.

Fig. 23. Device to prevent the explosion of grenades (perspective).

BRIDGE TRAINING OF A BATTALION OF MOUNTED ENGINEERS

By the Regimental Commander

Less than 5 per cent of the enlisted personnel of the battalion [under instruction] had been given instruction in military bridges. Instruction has been given in the following types of bridges: frame trestle, king post, queen post, wagon suspension, heavy and light ponton bridges.

The greatest difficulty experienced during this instruction was in getting the officers to organize properly and supervise the work of their details. As a general rule, military bridges will need to be constructed in the minimum time possible. This can only be done when the officer so arranges his details that all men are kept busy during the entire time. An officer detailed to construct a bridge should at once determine what part of the work is apt to delay the completion of the bridge, and take steps to have this work pushed energetically. In all bridge instruction, the senior instructor should have the bridge completely designed and the officers and non-commissioned officers thoroughly instructed in their duties, before the company is taken to the bridge site. Failure to do this will cause unnecessary delays and will give a wrong impression of the time necessary to complete the bridge. An engineer officer should know approximately the minimum time necessary, considering the conditions, required to complete the standard type bridges. It has been found that the best results are obtained by requiring all companies to build the different type bridges under exactly the same conditions. This creates a spirit of competition and forces the company commanders to plan their work and details before arriving at the bridge site. Bridges have been built by a company in one-third the original time required by another company because the officers had better planned and organized their work. Nothing so impresses the necessity of organization upon officers and non-commissioned officers of one company as to have another company, properly organized, complete a piece of work in less than half their time.

FRAME TRESTLE BRIDGES.

As soon as the site of the bridge has been designated, the officer should personally supervise the measurements to determine the number and height of trestles. The construction of the maximum number of trestles possible should be begun at once, allowing a sufficient number of men to prepare the sites for the sills. The first trestle should be in place in half an hour after the bridge site has been designated. One officer and 40 men constructed in 2½ hours an excellent frame-trestle bridge, 70 feet long, across a ravine 16 feet deep with steep rocky slopes. This bridge was built to carry a 3-ton truck loaded. This work was properly organized and pushed energetically.

[The regiment] has had considerable training in building framed-trestle bridges [on a river having] a current of 4 miles an hour and a soft silt bottom. The principal difficulties in building trestle bridges in rivers of this type are in placing the trestle in the swift current and in preventing the trestle from settling, due to the swift current scouring out the soft bottom under the sill. The following methods were used to prevent settling, due to scouring:

(*a*) Four-foot lengths of 3 by 12 inch plank, spaced 3 feet apart, were spiked at right angles to the bottom of the mud sill. These prevented settling where the current did not exceed 2 miles an hour, but in swift current the trestles settled during the first 24 hours from 2 to 3 feet when the roadway was placed on the trestle.

(*b*) The same method as above, except that two wagon loads of boulders were placed around the mud sill after the trestle was in place, but this failed to prevent the settling.

(*c*) The mud sill was sunk 2 feet into the bed of the river and boulders placed around the sill. These trestles did not settle as much as the others, but this method was not satisfactory.

(*d*) A mat of large boulders was made on the bed of the river where the trestle was to be placed, extending 4 feet upstream from the end of the sill. The trestle was placed on this and the sill covered with boulders. The trestles settled about 3 inches as soon as the load was applied, but after this there was practically no settlement. One trestle was loaded with 7,000 pounds for 24 hours and no settlement was noticed.

Heavy framed trestles are exceedingly difficult to place in swift currents. No difficulty was experienced in a current of 2 miles an hour. Several methods were used in placing the trestle in

swift currents. The following one was the most successful. A ponton boat with up and down stream anchor cables or shore lines attached, was brought alongside the last framed trestle or abutment. Stringers were lashed to the far gunwale, and the boat shoved off until the end of the stringers were just inside the site of the trestle to be placed. A floor was laid on the stringers. The frame trestle was carried out on this platform and placed on the rock mat. This platform can be used in making the rock mat, if desired. The boat should be kept in place until the trestle is leveled, the stringers nailed to the cap, and the mud sill covered with boulders.

These bridges were constructed during the dry season, and no

Fig. 1. Frame Trestle Bridge. (The detail at the center of the bridge is changing a road-way bearer.)

extra precautions were taken to guard against sudden rises in the river. Frame-trestle bridges can, under ordinary conditions, be built at the rate of at least 30 feet an hour, provided material is available and the work is properly supervised.

SUSPENSION BRIDGES.

It is realized that bridges of this type (Fig. 2) will be built only under exceptional circumstances. Instruction was given in this type of work in order that the battalion might be prepared for the emergency in case a suspension bridge should be necessary, also for

instruction in organization of working details. A bridge, designed to carry light trucks, wagons, infantry and cavalry in column of twos, and light artillery, with a span of 230 feet was built across the . . . [river]. The data given in the Engineer Field Manual was used and proved to be correct. The length of cable and slings specified gives a bridge of suitable camber.

The chief difficulties in a suspension bridge are in placing the anchors for the main cables, and in getting cables and slings adjusted to proper measurements. If turnbuckles of sufficient strength are available, so that they can be attached directly to the dead-man or anchors, the main cables and slings should be carefully measured, assembled, and clamped together on the ground. This will save considerable delay in adjusting cables and in placing slings and clamps on them, after they are hanging in the air. The assembled cable should then be pulled across and hooked onto the turnbuckles, and later raised over the towers by means of a gin or stiff leg.

A gin pole should be erected to raise the tower in place and later used to place the cable on the tower cap. Inexperienced officers will, as a rule, so rig their gin pole that the blocks will jam before the cable is high enough to clear the tower cap. The flooring should be laid from both ends of the bridge. A company of 80 men finished the entire floor system of this bridge, complete with guard and hand rail, in 1 hour. Another company took approximately 5 hours. It was purely a matter of organization and push.

Owing to the difficulty of getting a suitable anchorage for the dead-men, the company that built the bridge first was directed in dismantling the bridge to leave the dead-men, with turnbuckles attached, in place. All other material was taken down, cables, slings, and towers taken apart, and lumber piled with nails pulled out. Starting with material in this condition, a company of 70 men completed the bridge in 6 hours 45 minutes. The time required for dead-men depends upon the nature of the soil. [I consider this to be about the minimum time for this work.]

QUEEN-POST BRIDGES.

In building queen-post bridges, the trusses should be entirely assembled on the bank with the roadway bearers in place. Company commanders often assemble the bottom chord and put it in place, then assemble the remainder of the truss on the chord. This

necessitates handling heavy timbers under difficulties and occasionally ends up by overloading the bottom chord, causing it to break and fall into the ravine or river below. If this does not occur, much time is lost in assembling the truss. The timbers for a truss strong enough to carry a 3-ton truck, or a heavier load, weigh several hundred pounds apiece, and are heavy enough to handle, even on the bank. After the two trusses are assembled complete and rolled out on the abutment (as shown, Fig. 224, *Engineer Field Manual*), two shears, one astride each truss, can be used to advantage to place the truss in place on the far abutment. The shear legs prevent the trusses from overturning; also insure being

Fig. 2. Suspension Bridge. (This bridge was built with the exception of the anchors, by a company of 70 men in 6 hours and 45 minutes.)

able to raise the end of the truss high enough to rest on the abutment.

A queen-post bridge was built of 3 by 12 inch plank spiked together to form the trusses. Steel cables were used for roadway bearer supports. This bridge was strong enough to carry 6-inch howitzers without appreciable vibration.

PONTON BRIDGES.

The instructions in the *Ponton Manual* are so complete that it may seem unnecessary that anything further should be written on the subject. This battalion has recently completed a course of

instruction in ponton work . . . The swift current, at first, caused considerable delay. None of the company officers or enlisted men had ever worked in a swift current, and very few had ever had any ponton instruction at all.

The following principles apply to ponton work in swift current:

(*a*) Never push a boat off from the shore, unless all members of the crew have their oars in the oar-locks or in such position that they can put them in place as soon as the boat is clear of the bank.

(*b*) When attempting to cross a stream, the bow of the boat should be kept upstream and the axis of the boat should make an angle of about 30 degrees with the direction of the current.

(*c*) As soon as the anchor is cast, the non-commissioned officer must keep his boat in hand and the bow of the boat pointing always toward the head of the bridge. The boat then acts as a flying ferry and the current will push the boat towards the bridge-head. Failure to do this will cause the boat to drift with the current, and frequently the crew will find themselves yards away from the head of the bridge, when their boat is needed.

(*d*) Crews with little training can make little, if any, headway against a swift current.

(*e*) In bridging streams of 500 feet or less width considerable time and annoyance can be saved by stretching a rope across the stream where the anchors are to be dropped. In carrying the rope across, the coil should be placed in the stern of a boat and the rope played out as necessary. If the boat crew works properly, this rope can be put across in a very few minutes. The anchor boats are taken out on this rope, until each is opposite its place in the bridge. The anchor is then cast and the boat allowed to float down to the bridge-head. The use of the rope prevents anchors being dropped in the improper place and saves many delays that ordinarily occur, due to anchor crews allowing boats to get out of control. Anchor crews frequently allow boats to float against the bridge at right-angles to the current. A boat in this position is very difficult to remove, as the force of the current is so great as almost to upset the boat. It is practically impossible to handle light equipment, with anything like reasonable speed, in a river with a swift current without this rope to carry the boats out on. Two men pull on the rope hand-over-hand, with the rope resting inside the near bank mooring post or inside one flange of the anchor. The current drives the boat across the stream as in the case of a trail ferry, and a good crew will take a boat across a stream on a rope faster than a man can walk. If one or, preferably, two "Evinrude" motors are available, they should be used on the light ponton boat to assist the crew in carrying the rope across the stream. If motors are not available, the boat must be taken

upstream before being launched, as considerable distance will be lost in getting across.

(*f*) Practically no downstream anchors are necessary on a bridge built in swift current, particularly if the bridge is at right-angles to the current. The force of the current prevents the vibration ordinarily noticeable in bridges built in still water. A company in column of fours double-timed in step across a light ponton bridge with no downstream anchors, without causing any appreciable vibration. A heavy ponton bridge, with no downstream anchors, was used across the [river] for two weeks.

A company of 80 men of this battalion built a heavy ponton bridge (Fig. 3) 225 feet long across the [river] in 19½ minutes, an average of 11½ feet per minute. The bridge consisted of eight

Fig. 3. A Ponton Bridge.

boats and two trestles, one at each bank. Another company built one of same length (Fig. 4) by moonlight in 29½ minutes. A company of 80 men built a light ponton bridge 295 feet long, consisting of 15 boats and 2 trestles, across the same river in 29½ minutes and built a bridge of equal length by searchlight in 39½ minutes. This time included the assembling of the boats. All materials were piled as prescribed in the *Ponton Manual*. The rope system of dropping anchors was used on all of the above bridges.

The companies had only 20 hours instruction in the use of that particular class of equipment before the bridges were built in the lengths of time given above. Instruction was given all men in row-

ing, lashings, use of trestles, dropping anchors, loading and unloading equipment, and bridge construction. Since the bridges were built in a swift current, and with so little time spent on instruction, it is thought that the results were exceedingly satisfactory. Any company of this organization could have built any of the above bridges at the end of the instruction period in approximately the same time as that given.

Delays in building ponton bridges in general, due to the following:

Fig. 4. A Ponton Bridge. (Built at night.)

(*a*) Unnecessary time used in placing abutments and trestles:
(*b*) Slow balk lashers;
(*c*) Delays caused by anchor crews failing to have boats at the bridge head in proper time.

When it is absolutely essential that bridges be built in the minimum possible time and sufficient men are available, the following suggestions will increase the speed of constructing the bridge:

(*a*) Use 15 lashers instead of 10. Five lashers work in the boat shoved off, and perform the duties of front rank lashers (as given on p. 68, par. 20, *Ponton Manual*). The other ten lashers shove off last boat and then make the balk lashings, five lashers making near gunwale lashing, and five lashers making far gunwale lashing. The

chess laying should start just as soon as the near gunwale lashers have made the 3 turns around the balk. The lasher can work underneath the chess to complete the lashing. This arrangement will save about one minute per boat.

(*b*) Unless the water is over 4 feet deep or it is too cold, trestles should be placed by men getting in the water. The trestle and abutment for the far bank should be carried across the stream and put in place during the construction of the remainder of the bridge. This will save from 10 to 20 minutes.

(*c*) Have sufficient anchor crews to insure having boats at the bridgehead on time. Very few ponton bridges will be built in swift current without delays due to boats failing to arrive at the head of the bridge in proper time.

PILE BRIDGES.

All companies were given instruction in driving piles with a large framed pile-driver. A bent of three piles was driven in 45 minutes with the pile-driver overhanging the last bent driven. Two crews should be used on the hammer line, one crew walking back as the other one walks out in raising the hammer. Square timbers can be used for piles, when round piles are not available. The ends should be well sharpened and the square edges rounded off. The head of the timber must be protected by an iron band or wrapped with wire or rope to prevent splitting.

INSTRUCTION OF ENGINEER TROOPS WHILE IN QUARANTINE.

By the Regimental and Company Commanders.

[The presence of an epidemic made it necessary to place quarantine restrictions on the troops. During the period of quarantine all guard administrative duties were left to the remaining companies.] Effective instruction of the companies confined, however, has been pursued by way of indoor model work, lectures, etc. In addition, quarantined companies have very creditably driven galleries from beneath their barracks buildings under the open spaces adjacent thereto. In this gallery work, one company has sunk three shafts and driven 54 feet of gallery, and the second company two shafts and 45 feet of gallery. Shafts are cased and driven to a depth of 12 feet. Galleries are 4 by 6 feet in section, upheld partly by 3-inch casing and partly by frames with driven sheeting. (See Figs. 1, 2, 3.)

Companies not restricted by quarantine limitations have undergone instruction in out-door engineer drill to the extent that weather would permit supplemented by indoor lectures, each of which has been carefully and deliberately prepared by the lieutenant to whom assigned.

All companies have been "sectionalized," with a company lieutenant assigned specifically to each section, and responsible for its instruction and progress.

Company pack transportation has undergone initial drill, which will be extended during the coming month under the presumption of improved weather conditions, and the elimination of quarantine restrictions.

1. *Every man in company qualified in knots and lashings*—

(*a*) Men were divided into sections consisting of about twenty privates and two non-commissioned officers. As soon as the differ-

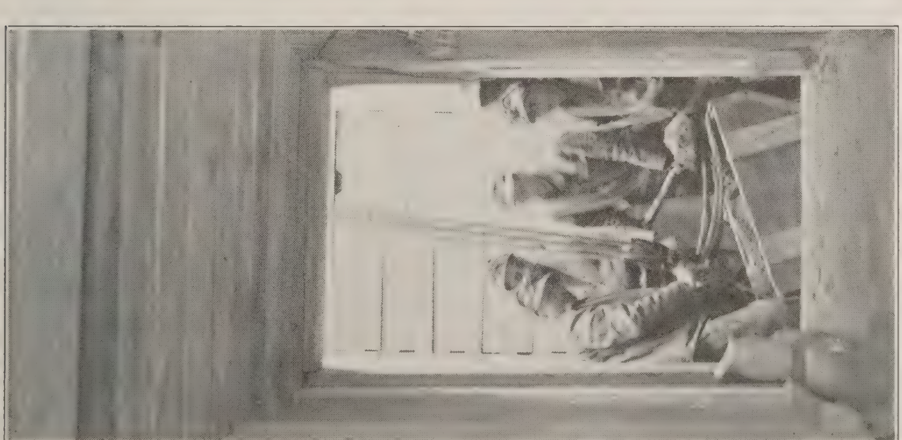


Fig. 1. Gallery entrance at bottom of shaft.

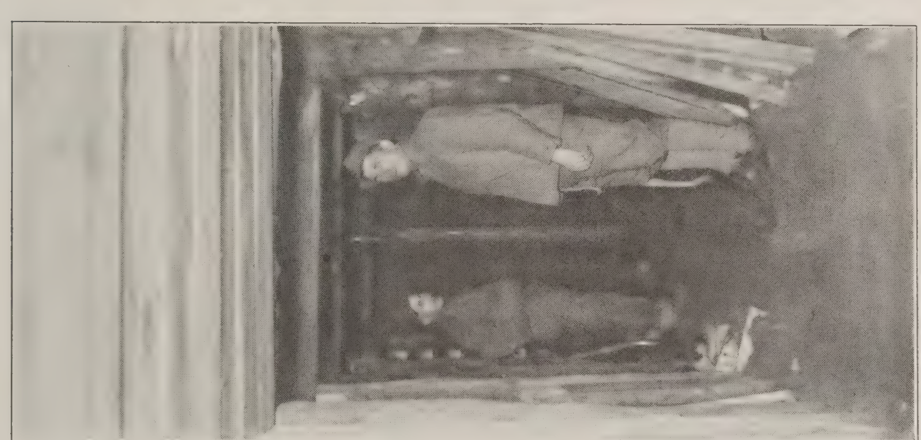


Fig. 2. Gallery looking towards head.

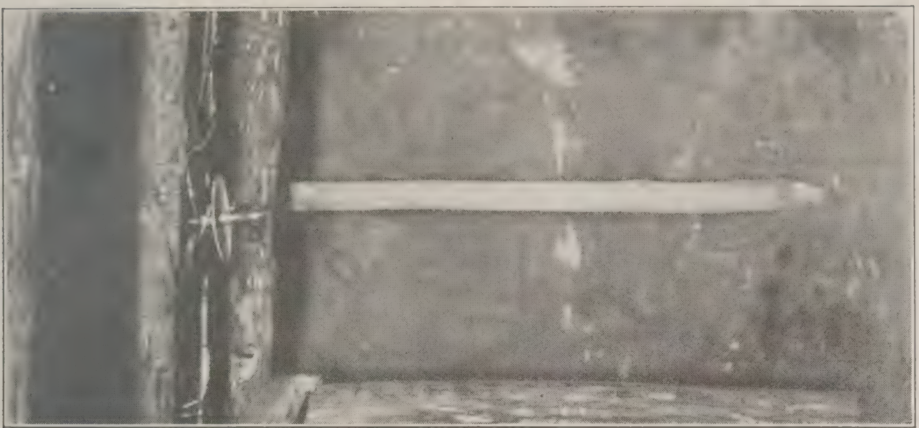


Fig. 3. Head of gallery.

ent men knew the knots and lashings they were sent to another section, where they qualified or were returned to their section for further instruction.

2. As soon as qualified they were sent to other tables for instruction in Semaphore.

. . . .

1. *Reconnaissance Section*—

(*a*) Explanation of what reconnaissance work consisted of; use of reconnaissance sketching equipment. Pace scale; how to make sketches by intersections; contours.

(*b*) How to read contour maps and make same. This was worked out thoroughly with use of a sand box.

(*c*) Each man made his own pace scale, measured a known distance, making his pace scale from this. Then making a sketch of the floor plan of the lower and upper squad room.

(*d*) Went over all data which should be used to procure a road reconnaissance; explained conventional signs.

2. *Bridges*—

Construction of ponton, spar, single and double lock, suspension bridge, double-bow string-truss, lattice truss, bridges. (Figs. 4, 5, 6, 7.)

This section has had lectures on these different bridges. Where and how to use them.

The bridge section has (through the use of a sand box) been instructed in small bridges of concrete, the building of forms for concrete bridges.

3. *Roads*—

(*a*) The road section have taken up military road building under all conditions.

(*b*) The difference between military road building and road building in civil life was explained.

(*c*) The following roads have been built in miniature:

1. Crushed stone; 2. Plank; 3. Charcoal; 4. Gravel; 5. Broken stone; 6. Water-bound macadam with telford, crushed and field stone base;

(*d*) Drainage, slopes, cuts, fills and varying conditions of same were also taken up.

(*e*) The following culverts have been built in miniature—

1. Concrete; 2. tile; 3. wooden box; 4. barrel; 5. stone.

(*f*) Arch culverts have been taken up in full detail. (Figs. 8-9.)

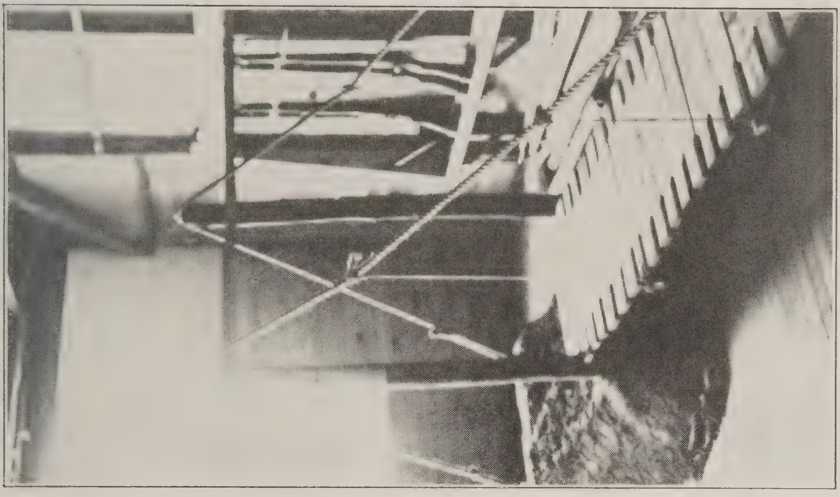


Fig. 5. Suspension bridge.

Fig. 4. Suspension bridge.

(*g*) Work and conditions as we will find them "over there" have been explained as learned from pictures and lectures.

(*h*) Have read to the section articles from engineering manuals and books which are considered very good authority on the subject.

4. *Field Fortifications*—

(*a*) Lectures and instruction in the building of trenches and field fortifications.

(*b*) Constructed fascines, hurdles and gabions from material which was obtained by the company while on morning hike.

(*c*) Construction of firing trenches in basement with the use of sand-bags and miniature revetments which were constructed in the mess hall.

(*d*) Explanation of trench drainage and use of trench pumps.

(*e*) Wire entanglements that may be constructed in a trench and carried out were made of plain wire. No barbed wire was available.

5. *Demolition*—

(*a*) Work done in this section consisted of lectures on the use of various explosives and the most effective places to place the charge.

(*b*) Dynamite and triton were the principal subjects.

(*c*) Explanation of the use of the electric exploder. Method of connecting several mines together in order that they may be exploded simultaneously with the exploder.

(*d*) The explanation of mines, how to make and load them.

(*e*) The use of galleries, how to make them, and what they are for.

(*f*) Explanation of the use of hand grenades and bombs.

(*g*) How and where to place the charge where they will be most effective in railroads and tunnels.

6. *Signal Section*—

(*a*) This section first learned the two-arm Semaphore code by pairing off with one set of flags. One man sending and the other receiving.

(*b*) When nearly all men attained the speed of forty letters per minute they were started on the general service code. When the entire section had learned the alphabet fairly well, the fastest men sent messages by wig-wag. Letters, words, sentences, and letter codes were received by the rest of the section.

Fig. 6. Double bow string truss bridge.

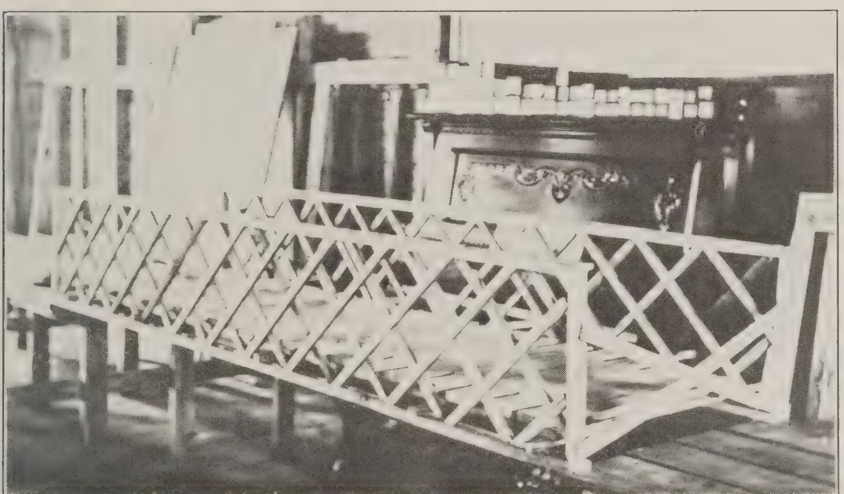


Fig. 7. Lattice truss bridge.

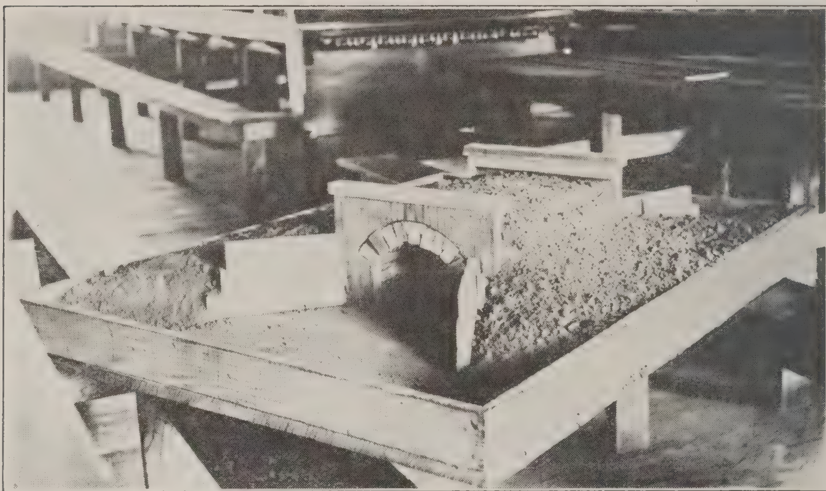


Fig. 8 Arch culvert built of wooden blocks in a sand box.

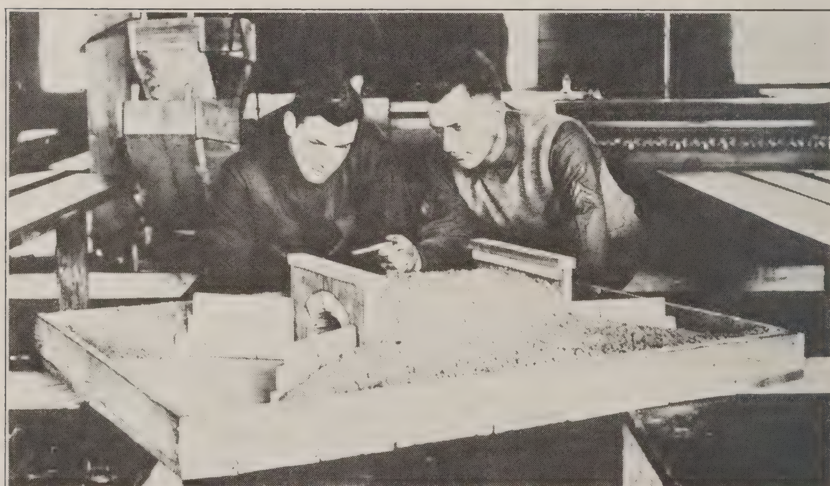


Fig. 9. Arch culvert built of wooden blocks in a sand box.

Fig. 10. Trenches in miniature.

Fig. 11. Gabion, fascine and brush revetment.

7. *Transportation*—

(*a*) This instruction was carried on by lectures, as there was no way to demonstrate to this section.

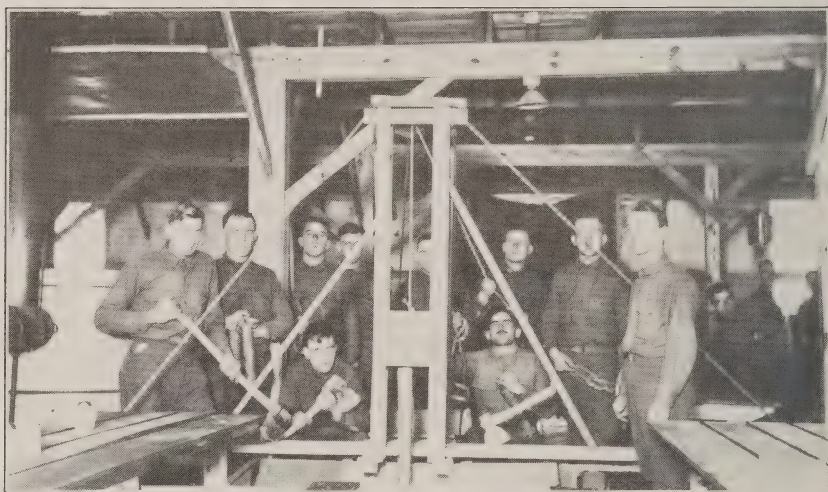
(*b*) The care of animals:

1. Ration; 2. Treatment of diseases.

(*c*) Treatment of animals while using them.

(*d*) Loading of wagons, ponton wagons, and packing packs.

(*e*) The pack train was explained in detail. There are only two methods of transportation used by the Engineers in the mounted section. Wheel and pack being explained thoroughly.



Piledriver.

8. *Administration*—

(*a*) Study of Company Administration (by Waldron), and Engineer Training Manual, Appendix No. 2, Instruction for the use of company forms.

(*b*) General office work.

(*c*) Finished correspondence book. Worked-out index system. Checked and completed blank books pertaining to qualifications, etc.

(*d*) Mess sergeant and cooks, usual duties:

1. Qualified in knots and lashings.

(*e*) Company clerks did manual of arms and physical exercise daily.

THE BATTLE OF THE SOMME.[1]

Lecture delivered by Capt. A. V. Gompertz, M. C., R. E., at the Officers Cadet Unit, Lower Topa, and later at Murree.

My lecture, Gentlemen, is divided into eight parts as follows:

1. Introduction.
2. The Importance of the Somme.
3. The Objects of the Battle.
4. The Chief New Features of the Battle.
5. A Rough Sketch of Events.
6. Some Features of Interest.
7. The Results of the Battle.
8. Its Lessons.

These I shall treat in detail, taking each as a separate chapter.

1. *Introduction.* To treat of the history of the Battle of the Somme in an hour and a half is as impracticable as to run through the history of Europe in a day.

Moreover, you can all buy detailed histories on every railway bookstall.

All I propose to do now is to give you a rough trace of the events of the battle, coupled with a few comments, and also with the mention of some points which seemed to me at the time to be of particular interest.

It will only be possible, in the time at my disposal, to deal with the British portion of the offensive, and not with the French attacks, which were going on concurrently on our right, with perfect coördination and perfect success.

The lecture will only comprise the actual Battle of the Somme, and not the action of November the 13th, 1916, by Sir Hubert Gough. That I have considered as an isolated and brilliant success at the end of the battle of the Ancre.

There seem to be some differences amongst writers as to the

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[1]Reprinted from *Journal of the United Service Institution of India*, October, 1917.

real distinction between the battles of the Somme and the Ancre. The Ancre is a northern tributary which joins the Somme very much west of the fighting area, after having flowed south, just west of that area, until it has reached a point very near the actual Somme.

For the purposes of this lecture therefore, I have taken the operations of Sir Henry Rawlinson's Fourth Army, which fought in conjunction with the French close to the Somme River, to constitute the Battle of the Somme.

The work of Sir Hubert Gough's Fifth Army, which fought strictly in or near the Ancre Valley, north of the Albert-Bapaume road, I have classed as the Battle of the Ancre. This latter battle therefore commenced in July alongside, and a little later than, that of the Somme.

On September the 26th when the fall of Guedecourt and Combles closed the Somme proper, the Ancre campaign, taking Thiepval that day, stopped for a halt only, preparatory to its final effort, the taking of Beaumont Hamel and Beaucourt in the middle of November.

I wish to make one small personal note, regarding my qualifications to talk to you here to-day.

Although not by way of doing rifle and bayonet work myself, I was present throughout the whole campaign of the Somme in the fighting area, under circumstances which allowed me exceptional facilities for observation.

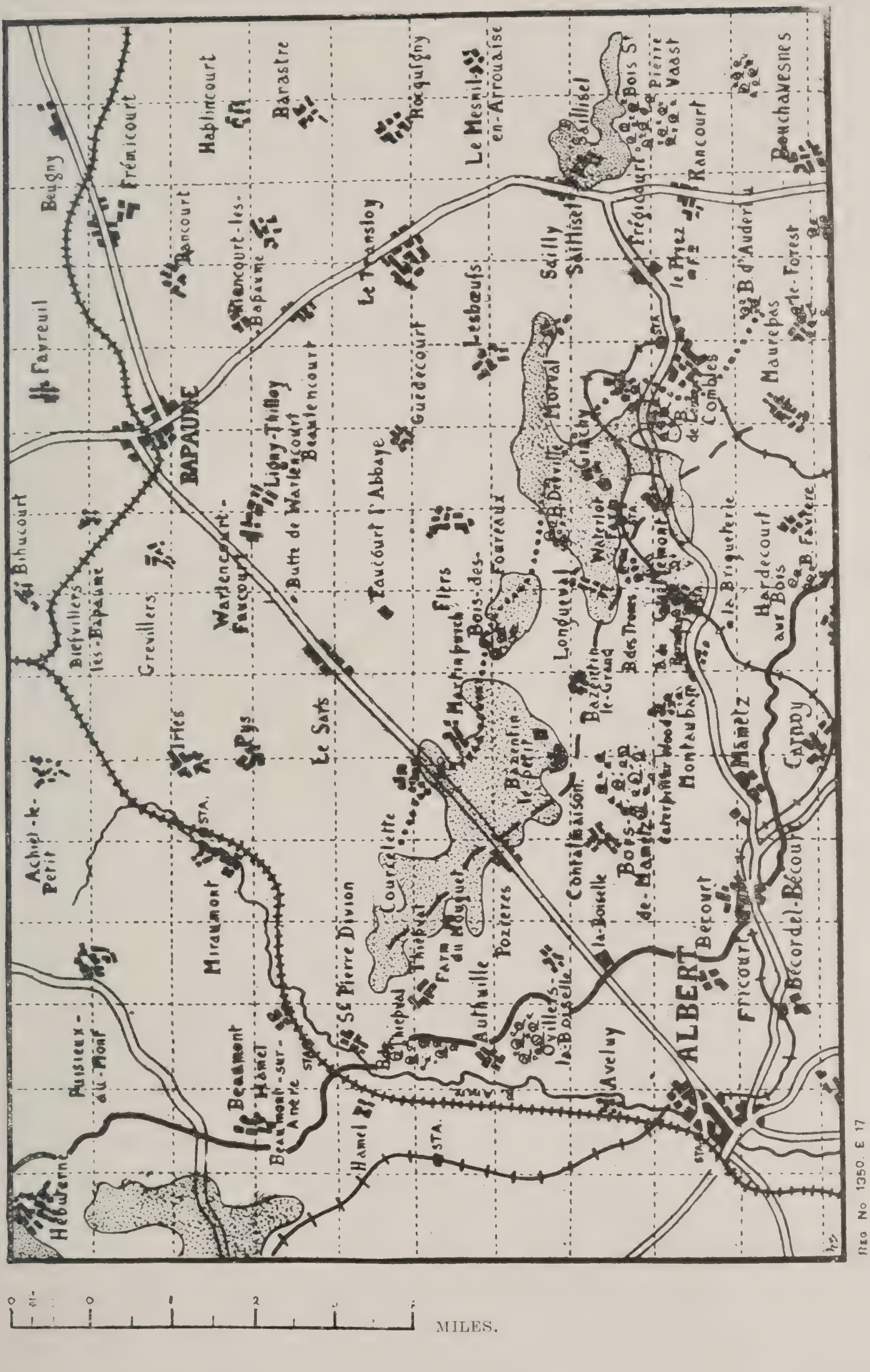
All that you hear, therefore, will be the result of close touch with facts; and nothing will have been taken in any way from other writers' works, except one or two dates of events away from my own immediate front.

2. *The Importance of the Somme.* This I take under two headings:

A. The first is an aspect which could be well seen by every man in the ranks.

It was, that on the Somme we definitely and finally gained the initiative in the west, which Germany had possessed uninterruptedly for nearly two years.

From August, 1914, right up to the end of 1915 the British troops were completely the under dog. Those of you who were there in those days will remember the real cloud under which we


BAPAUME
ALBERT
Le Sars
Flers
Combles
Mametz
Carnoy
Fricourt
Contalmaison
Pozières
Thiepval
Longueval
Guillemont
Montauban
Martinpuich
Courcelette
Miraumont
Beaumont
Hamel
Aveluy
Authuille
Bécourt
Bécordel-Bécourt
Maurepas
Rancourt
Bouchavesnes
Sailly
Lesbœufs
Gueudecourt
Le Transloy
Morval
Ginchy
Grevillers
Irles
Pys
Achiet-le-Petit
Hébuterne
Bihucourt
Favreuil
Beugny
Frémicourt
Haplincourt
Barastre
Rocquigny
Le Mesnil-en-Arrouaise
Ligny-Thilloy
Beaulencourt
Warlencourt-Faucourt
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lived. In men, munitions, and devices, we were infinitely inferior to the enemy.

Each time we attacked, one heard the same plaint: "We had him dead beat, if only we had had a couple of fresh divisions to follow up with." But we had not, and his overwhelming counter attacks used to sweep us out of almost every bit of ground we gained.

In artillery and munitions too be had incalculable superiority. Reprisals were unknown or negligible. We could only send over a couple of field gun rounds to his dozen of heavies.

In devices too he had the best of us; he killed us with gas before we knew what it was, he sent us from his trench-mortars ten-inch "Rumjars" dated 1913, whilst we threw back little projectiles made from half a 13-pounder cartridge case.

We never knew of fresh divisions behind us; our last defences on the road to Calais and Boulogne were the choppers of our own cooksmates. At all times it was not "What are we going to do?" but "When and where is the enemy going to launch an overwhelming offensive that we cannot hope to stop?"

At the beginning of 1916 came the change. It came by degrees, but those degrees were of the most marked surety and followed one another in quick succession.

Fresh divisions appeared behind us from nowhere, fresh Corps even: transport bearing unknown marks began to be common in the streets of Hazebrouck, Merville, and St. Venant.

Ammunition too began to arrive in hitherto unheard-of quantities. My own Division in those days marvelled greatly because they were allowed to send three hundred rounds of 18 pounder over one night, at a big massing of German transport which our I. D. had (extremely accurately) anticipated near Aubers.

Fresh guns too came up slowly, sixty pounders and 8-inch howitzers began to increase and multiply; ordnance stores too got better in super-efficiency and were more quickly and freely served.

I don't think we had definite ideas of a big offensive yet; but by March or April, 1916, the period of dark misgiving was entirely a thing of the past. We had equal strength with the enemy, and every man in the front line felt the difference and was correspondingly happy.

By June, 1916, we were literally flooded with guns, men, and

ammunition; and we then had, what everyone felt and knew, Great Strength, on a leash so to say.

The last German attempt to keep the initiative in the west had failed at Verdun, due to the magnificent stamina of the French.

On the first of July, 1916, our strength in leash was let loose; and from that very day we took to ourselves the initiative in the west, which we can never conceivably lose again.

That was the first Importance of the Somme.

B. The second point of importance was one which concerned commands and staff in the first place, but each and all under them in effect.

That was, that every man in the west is now fighting day by day on what he or his teachers learned on the Somme.

There have been only minor developments of small kinds this year, in the tactics learnt as successful on the Somme, and practically not one single new feature since.

C. Perhaps a third matter one might touch on will constitute a third importance of the battle; namely its correlation with after events.

It was the direct begining of the continual offensive which will end the war:

(a) The Somme began on July the 1st, and made a doorway for the Ancre campaign which joined it towards the end of that month;

(b) The Somme and the Ancre proceeded side by side until the Somme was over on September the 26th, and the Ancre halted.

(c) The Ancre had its finale on November 13th to 17th, when we took Beaumont Hamel and Beaucourt.

(d) At the ends of these two campaigns we knew that the enemy would have to go back. It was merely a question of time, the weather treated us cruelly. Without that, the Great Retreat might well have been forced under winter conditions. Thus the Somme, and with it the Ancre, brought about the Great Retreat (March, 1917).

(e) The Great Retreat brought about the Battle of Arras: a threat to its own right.

(f) Since the battle of Arras, there has been nothing but straightening out of the line, preparatory to the next big offensive. This, I have reason to believe, will take place actually in a day or two.

(*N.B.* This lecture was originally delivered on the morning of August 1st, before any news had come through).

Two instances of straightening the line are our own very successful operations at Messines and Witschaete; and the good, but very minor, work of the enemy by Dixmude.

Thus this third aspect of importance of the Somme becomes clear, in that it was in no way an isolated operation, but the first link in a great and strong chain.

In more ways than one, it was The Beginning of the End.

3. *I now come to the objects of the Battle.* These were three, excluding Political and International ones which do not concern the fighting soldier.

A. The first was, to kill as many Germans as possible, and to incapacitate and capture as many more as possible.

This, the most important object, you will recognize as coming straight from the text books, *viz,* the Destruction of the Enemy's Forces in the Field: the oldest principle of war.

When Samson slew his hundreds with the jawbone of an ass, we are not told that he gained an acre of ground in so doing.

B. The second object, was to reconquer as much territory as possible. This was subsidiary.

C. The third was, to gain the Initiative and to keep it. That I have touched on already.

When talking of the objects of the Battle, one is led naturally to consider the possibilities it entailed.

These were three in number.

1. That we should break right through the German line, and force the enemy right back into his own country.

2. That we should break through gradually, and to a certain distance, before winter perforce put a stop to field operations.

3. That we should not be able to pierce the enemy's line at all.

All these three had to be legislated for, and completely coördinated arrangements had to be made for each.

Unlike our enemy on previous occasions, we did not work out the most probable one and say "I reason that it must go so; therefore it will go so."

The great weight of opinion that one heard, and, I think I am right in timidly saying, the personal opinion of the Commander in Chief, was for the second alternative.

But all three were very fully legislated for, including of course the possibility of very heavy counter attacks under 2 and 3.

One more matter may be touched on here, which may be said to be a fourth object of the battle, arising after the second of the possibilities had actually materialized.

That was, to secure a pounded finish. By the time that the year's fighting was over, we held the commanding ground and every advantage that it gave, over the whole front of the offensive.

We had better ground, better observation, and better communications as far as the ground served, from Beaumont Hamel to Combles, than the enemy.

The conditions for the then under-dog in the winter were, we knew, unbearable, and we meant them to be. It was thus that the Great Retreat was assured in reality before the last day of November, 1916. The weather, and nothing else, postponed it till March, 1917; and on that account, the weather having hindered us abominably too many times in the summer, we allowed the possibility of a substratum of truth in the enemy's eternal "Gott mit Uns!"

4. *Salient New Features.* There were many new features on the Somme: I have only selected nine, which appear to be worthy of special note and seemed to be especially new.

These were:

I. The battle was our first really large and determined offensive. As one paper put it, it was the first time we had taken up the offensive on a scale worthy of the Empire. Some ten divisions were launched in the first attack, making 200,000 troops directly concerned. The actual number of men who climbed out of the front line trenches at zero must have been at least in the neighborhood of 10,000.

Those of you who were in the attack of the 25th of September, 1915, afterwards miscalled the battle of Loos, will remember that that took place on a very wide front.

The Meerut Division went over in front of Fauquissart, whereas the southernmost attackers were well south of Loos.

But that day there was no backing and there could not be: we had not the men in France. The attack was vitally necessary: the numbers of men to turn it into a Somme were not yet in the field.

On the Somme however, although, as mere miles go, we only

attacked on a slightly wider front, there was a weight of men ready and fresh behind the attackers, divisions and army corps to spare.

II. The second salient new feature I have selected was the enormous number of troops who took part in the battle between June and November.

Going on the principle that a division "expended" (very badly hit about and sent back to refit and bring up its often pitiable numbers to full strength again) counts as a new division, when it comes up fresh and recouped to fight again, something like 240 divisions of all sides were engaged. (British, French, and enemy.) Add to that the very large numbers of Corps Troops and Army Troops, administrative units, medical units labor units, etc., that played a very direct part in the operations; and the sum total concerned must be in the neighborhood of 5,000,000.

III. The third new feature consists of six points of material difference in our Artillery.

(a) The enormous masses used. The whole countryside behind the front was dotted with guns, of all sizes, calibres and natures. I cannot give actual figures but they were colossal.

(b) The extraordinary increase of calibre of guns used in field operations. The Divisional Artilleries became like glorified machine guns, and 60 prs, 6-inch, 8-inch and 9.2-inch howitzers were very common. There were also many 12-inch and some 15-inch hows; 6-inch and 12-inch naval guns, and possibly one or two 15-inch guns, though I am not at all sure of the last kind.

(c) The marvellous progress in accuracy of our guns and howitzers of all kinds. Direct hits were the order of the day; and the quick way the Kitchener and later gun-layers picked up very accurate shooting was a splendid surprise for all concerned. Especially perhaps for the enemy, barring the splendor; for the German puts such faith in his own long-trained regular artillery.

(d) The practically unlimited supply of all kinds of ammunition: a very great contrast to earlier days. Only on very rare occasions indeed was a single gun held up in its programme for lack of rounds; and even then it would be a question of transport rather than ammunition.

(e) The development and perfection of Creeping Barrages: that is to say, of barrages which go forward with the attacking infantry at a perfectly regular pace, and a surprisingly short distance ahead of them. The effect on the defenders can well be imagined, when, as is the fact, the accuracy of the shooting is of a high order.

I see that the press attribute the great share of work in inventing and perfecting these barrages to Sir Henry Horne, now commanding the First Army, then commanding the XV Corps.

(f) The development in size and mobility of our trench mortars. The Stokes and the other smaller-bore ones played a great part, especially in the final bombardments of objectives. But even the new 9.45-inch mortars, which throw close on to two hundred pounds of high explosive three quarters of a mile with good accuracy, were repeatedly advanced from position to position behind the attackers.

IV. The fourth new feature I have selected was the great development of tactical Bombing Work, in the clearing of won ground and the taking of lesser points, as approaches, etc. Bombing tactics were elaborated and standardized to a high degree, and produced invaluable results.

One day I had the good fortune to watch the taking of two trenches by bombing up them in conjunction with a creeping barrage. They were two trenches leading into Mametz Wood which we had not yet got; and their capture was an essential preliminary to the taking of the wood.

We watched the operation from the height of Pommiers Redoubt, about a mile or less away. The barrage went up in front of the party with perfect regularity and accuracy, and hardly a bomb thrown fell outside the trenches to be captured.

The whole thing may have lasted a quarter of an hour, and was a complete success.

V. The fifth new feature was our Mastery in the Air. This was noticeable from the beginning of June, and divides into three headings.

(a) The extreme bravery of our pilots. One need say no more here than has been said in our own press; but the enemy were by no means the least in acknowledging the superlative bravery of our men.

There was a most marked difference between them and the enemy. Our own men, unless acting under exceptional instructions, carried the war into the enemy's country with a vengeance. They took battle anywhere, and rode where they pleased. I believe the actual proportion of line crossing by the two sides was some preposterous figure near 200 to 1. That is, that for one enemy plane that crossed our line we crossed his 200 times. I can not give the actual figure, but from July to September it was enormous. One seldom seemed to see boche planes at all on our side of the line.

(b) The Mastery of the air. Owing to the policy of the pilots

which I have just mentioned, our men completely owned the air, as regards observation, air fights, and engaging troops on the ground.

When Hindenburg came to set things right in the west, there was a certain increase of German air activity: it was reported to us that he had "strafed" their airmenin no measured terms. But the result was not proportionate. The bravery and dash of our pilots made up for any inferiority of machines, and more than made up.

(c) The third feature was that, for the first time, the art of downing drachens (observation balloons) on a large scale was evolved. It was done by small fast planes with picked pilots; and, on one memorable day at the end of June, in order to conceal our final preparations for the attack, a round dozen of German drachens were sent down in flames in twenty minutes. Never before had anything more than one or two been thus treated, and that only at long intervals.

From our own Corps aerodrome, a Nieuport went up, climbing in his stride, straight for the German lines ten miles distant. At the end of the ninth minute his drachen sank in flames, at the end of the ninteenth he was landing again in the aerodrome, unruffled.

VI. The sixth new feature was the enormous development in the use of Motor Transport. Lorries were used in very large numbers indeed, and probably much further forward in the offensive than had ever been done before. In the notable shortage of light railways they did invaluable work in the forward area. It was to the great detriment of the roads; and much of their work has been now rightly taken by light railways. But they served their turn, and enlightened their owners as to the hitherto incredible amount of power and stamina that there is in a three-ton lorry if the emergency demands.

VII. The seventh new feature was our use of gas, gas shells, and the flammenwerfer. The novelty lay not actually in their use, but in the fact that, once having been the victims of these devices, we were able to beat the boche at his own game. It has been a most notable feature of this war that it is always he who has invented the new deviltries; and always we who, coming later into the contest, have outdone him at his own game.

VIII. Another new feature was our obtaining the mastery in mining. Like the gas, etc., in the earlier days of the war, it was we who used to get bad surprises in this direction. But on and before the Somme the position was completely reversed; and the utter success and unexpectedness of the Messines and Wytschaete mines,

some of them over a year old, is a larger example of what happened on the Somme.

IX. The last new feature of the Somme consisted of the Tanks. Here again the press has told you about all there is to say. One point is perhaps worth making.

After the great day of September the 15th, "Tank Day," when they were first used, one did not hear so much about them. There was a distinct tendency among some to say that they were a disappointment.

That I believe not to be the case at all. Since that first day they have become a routine article usable in very large numbers, and that, I think, is the only reason that they no longer get the big type in the papers.

The first German use of seventeen-inch shells created just the same class of stir: nowadays huge shells are so common on land as never to get a press notice. And it is the same with the Tanks.

Naturally they have lost their first great element of surprise and will never make so big a bag of dead as they did on that day, but their efficiency remains.

From my own experience, after the attack of September 15th, the front German trenches by Flers had dead literally in heaps in them. We were inspecting them when we were caught by a stiff bit of enemy barrage, and, wishing to get down into cover, had literally to look about and choose an unoccupied spot to get down into. The ground too was littered with them that day: I think the defenders lost infinitely more than the attackers.

5. *The Fifth Part of the Lecture* consists of a rough sketch of the events of the Battle, the preparations and three phases.

A. The Preparations. These were commenced many months beforehand, and were gigantic. New railways had to be made, new roads to take motor transport, many old roads and bridges had to be altered to M. T. standard.

Vast supplies of ammunition had to be brought up and stacked ready for use in the big Dumps, and new sidings made for them.

A very large number of new batteries of large calibre had to be brought up and securely dug in position and protected, and arrangements made for their moves further forward.

The medical preparations were very great, new casualty clear-

ing stations were established with their own sidings, and new aid posts and dressing stations made.

The water supply arrangements had to be made in great detail, for an advance through a practically waterless country, save for the damaged village wells.

The engineer preparations too were enormous, comprising many of the foregoing ones as well as the accumulation and distribution of great quantities of Engineer Stores preparatory to an advance through a devastated country.

Those may be called some of the material preparations.

An enormous amount of work had also to be done in the training of troops for the assault: this being only one of the many duties of the staff who were "working overtime" for months beforehand, thinking out every conceivable detail. The work of the intelligence branch was very heavy.

The preliminary bombardment began about the 25th of June. I say "about," as there was such a continual pounding of the heavies in their registration, that the actual beginning seemed gradual.

The intensity of the bombardment was highly spectacular: at times the enemy line seemed nothing but a series of earth-fountains. One saw much go up in the air, sometimes the defenders of the battered trenches. Just before zero on July 1st, the line was hidden in a solid fog of earth-haze, through which the bursting shells showed dully.

In these days of the preliminary bombardment came the first prisoners of the battle; men who had been unable to wait for the attack, whose nerve had failed. They were a sorry looking lot, but they occasioned great excitement. It must have been the first time for many a day that the little French villages had seen their enemies coming back in more than ones or twos.

Zero was at 7.30 a. m. on July 1st.

At that moment Sir Henry Rawlinson's Fourth Army attacked, and the first phase began: that is, taking of the first German system.

The position was roughly as below:

NORTH.

VIIIth Corps opposite Serre.
Xth Corps opposite Beaumont Hamel and Thiepval.
IIIrd Corps opposite La Boisselle.
XVth Corps opposite Fricourt and Mametz.
XIIIth Corps opposite Contauban.

Before following out the first phase it is as well to define an army corps, as it is not a unit that existed before the war in our army.

On the western front, a British army corps consists of from three to five divisions: with an average of about four. On one occasion my own corps comprised six divisions, and on "tank day" five; but the average was four. Divisions were changed as they became expended.

Whereas the division remains, as ever, the tactical unit of coöperation of all arms, the corps has become, owing to the great numbers of troops on the Western front, the tactical unit of attack. It is seldom that one division of a corps secures a decisive success whilst the other fails. (Normally a corps attacks with 2 divisions in the line.)

Its numbers may be taken at roughly 90,000 men, *i. e.*, Four Divisions with quite ten thousand extra men in the way of Labor Units, Corps Artillery, Corps Engineers, and various Medical and Administrative units.

The progress of the first phase I will take by dates.

July 1st.

VIII and X Corps never in.
III Corps in as far as Contalmaison but driven right out again by counter-attacks later in the day.
XV Corps well in on both sides of Fricourt according to plan; and in possession of Mametz.
XIII Corps in possession of Montauban and its full objectives.

N. B.—The XVth Corps Commander decided not to go for Fricourt frontally, but to bag it from the two sides.

July 2nd.

III Corps get a footing in La Boissel.
XV Corps take Fricourt according to plan.
XIII Corps consolidate and straighten their front.

July 4th.

III Corps take La Boisselle after four days of terrific hand-to-hand fighting.
XV Corps take the aproaches to Mametz Wood.

July 4th and 5th.

Very heavy counter attacks by Thiepval and north of it: all fruitless.

July 7th.

The III Corps again take and lose Contalmaison; but in so doing, confront the 3rd Prussian Guard, the first arrival of the enemy Guards on the Somme.
Result, the Prussian Guard very severely handled, and 700 of them taken as unwounded prisoners.

July 8th.

XV Corps get most of Mametz Wood.
XII Corps get into Trones Wood.

July 10th.

III Corps take Contalmaison.
XV Corps progress in Mametz Wood.
XIII Corps repel continuous counter-attacks in Trones Wood.
(These went on all the week.)

July 12th.

XV Corps get the whole of Mametz Wood.

This ended the first phase: we were ready to attack the German second system.

These twelve days the fighting was utterly continuous, without rest or respite; counter attacks were perpetual and sometimes in very heavy force: and success was only assured by the spirit of attack being splendidly maintained by all ranks down to the lowest.

The best summary of them is in an extract from the Commander-in-Chief's dispatch of the 12th July.

He says:

"After ten days and nights of continuous fighting our troops have completed the methodical capture of the whole of the enemy's first system of defence on a front of 14,000 yards. This system consisted of numerous and continuous lines of fire trenches extending to various depths of from 2,000 to 4,000 yards, and included five strongly fortified villages, numerous heavily wired and entrenched woods, and a large number of immensely strong redoubts. The capture of each of these trenches represented an operation of some importance, and the whole of them are now in our hands."

It is to be noted that on July 13th our right was well in; whereas our left was stationary, limiting the breach.

The French were splendidly keeping pace on our right again.

B. The second phase lasted from the 14th of July until the 15th of September: namely the capturing of the second German trench system.

Zero was at 3.20 a. m. on July 14th; and the French attacked in conjunction on our right.

By nightfall, the front of the attack having been from Pozieres to Delville Wood, the situation was as follows:

July 14th.

III Corps took Bazentin-Le Petit and its wood.
XV Corps took Bazentin-Le Grand and its wood, the ground between that and Longueval, and part of Longueval and Delville Wood.
XIII Corps took the rest of Longueval and Delville Wood, and finally cleared Trones Wood.

This day's attack was brilliant in all parts. The enemy thought it impossible for us to attack again in force after such a short time.

We got in so far and so fast, that for the only time in the campaign of the Somme we released civilians from the conquered part of France. All the civilian population had of course been evacuated from within a certain distance of the firing line by the Germans: but on this day we got far enough in to overtake two people who had not gone back.

True, they were only two pathetic little girls, about five and seven years old, both wounded; but it heartened up the men who saw them, immensely. They were found in one of the Bazentins.

It was on this day that the Cavalry came into action, for the first time since 1914, as Cavalry. A squadron of Dragoon Guards and one of the Deccan Horse worked up the valley between the Bazentins towards High Wood, and did very good work.

July 15th.

III Corps got right to the outskirts of Pozieres.
XV Corps, advancing, broke right into the Third German Sytem in High Wood.

July 16th.

XV Corps withdrew their men from the Third German System in High Wood, as the salient formed was too dangerous; but kept a secure footing in the Wood.

July 17th.

III Corps took Ovillers.

Here came the real beginning of the Ancre Campaign; the Fifth Army coming into position immediately north of the Albert-Bapaume Road.

July 25th.

The Fifth Army (Sir Hubert Gough) took most of Pozieres.

July 26th.

Pozieres falls to the Fifth Army.

From now until September the 15th was a long period of preparation, and continual fighting, to secure jumping-off positions from which to attack the Third German System.

It was marked by severe hand-to-hand fighting, by furious counter-attacks (in one of these the enemy regained a footing in Delville Wood), and by battles for strong points and bits of villages that would have been considered great actions earlier in the war.

There was, however, no concerted attack along the whole line until all were ready.

The general aspect was:

FOURTH ARMY straightening and consolidating for its next attack, advancing continually.
FIFTH ARMY pushing hard to catch up with the Fourth Army and be ready for its own attack, also advancing continually.
IN SOUTH, the French always keeping pace.

Salient dates were:

August 23rd.

XV Corps drive last enemy from Delville Wood.

September 3rd.

Fifth Army advance a lot south and east of Thiepval and Mouquet Farm.
XV Corps get most of Ginchy.
XIV Corps (in relief of XIII) get Guillemont.

September 9th.

XV Corps get rest of Ginchy.

This finished the Second Phase of the Somme.

C. The Third Phase of the Somme was a brief one; namely, the taking of the Third German System on a selected front.

It began on September 15th, which was "Tank Day."

September 15th.

Fifth Army take Martinpuich and Courcelette.
III Corps take High Wood.
XV Corps take Flers.
XIV Corps advance to conform with XV.

September 25th.

XV Corps gets to the approaches to Guedecourt.
XIV Corps gets to the approaches to Combles.

September 26th.

Fifth Army takes Thiepval.
XV Corps taken Guedecourt.
XIV Corps (with French) takes Combles.
This last date was a great day, large quantities of munitions and stores were taken in addition to the many prisoners and the ground retaken.

This finished the campaign of the Somme proper, although minor advances were made from time to time to straighten out the line throughout October.

On November 13th-17th the Ancre campaign had a brilliant finish in the taking of Beaumont Hamel and Beaucourt by the Fifth Army, with 7,000 unwounded prisoners.

That last event closed the fighting in Picardy for the winter.

6. *I now come to the points of interest of the battle.*—The whole thing was so extraordinarily interesting on every day of its three months, that it is very difficult to pick out things more interesting than others. I have picked out eleven things, more or less haphazard.

A. The great bravery of all arms, but in particular of the Infantry, in the face of shell fire undreamed of before the war.

Field gun shells and 4″ shells were quite minor worries. Even the 5.9″ (the "crump") sometimes became so; there was such a plethora of heavier stuff.

I have heard an infantry company commander tell his platoon commander to "Get on now, they're only crumps now."

Medium stuff, 6″, 8″, and 9.2″ was the order of the day in

front; and heavy stuff, 10″, 11″, 12″ and even larger were far from uncommon.

Our men faced it all calmly, even in the open.

B. The second thing was the bravery of our wounded, at all times and in all places. I was in a position to see them long before they got back to the kindly ministrations of the Field Ambulances, much less the casualty clearing station; and they were always the same.

They provided the greatest possible contrast to the wounded enemy prisoners, both in attitude and fortitude. As a whole, the British wounded man stands pain, the other does not.

C. The Personal Equation was very strongly brought out on the Somme, and closely watched. Before this war it was sometimes left entirely to such writers as Ole Luk Oie to insist on it. On the Somme every trait of an opposing commander was studied, and their photographs were lithographed and circulated to aid the study.

The personal equation found its solution from the highest right down, naturally being longer of solution in the higher stages. Whereas a British platoon commander would knock out his opposite number in perhaps half an hour or less, battalion and higher commanders would of course take longer.

I believe I am right in saying that the XV Corps Commander's opposite number was General der Kavalleme von der Marwitz, who was sent back after a matter of days rather than weeks.

Whereas Count Sixt von Armin, the approximate opponent of the Fourth army, lasted some three months, by virtue of being in higher command. Then he too had to pack up, his retreat only being postponed by the winter. I do not think he was deliberately relieved, as von der Marwitz was reported to have been.

D. Another point of interest was the way one could always tell how the day had gone, if there was an attack on, coming up from behind. If things had gone well, there was the most unmistakeable medley of wounded, prisoners, and wounded prisoners, coming westwards. They would be all inextricably mixed up; the prisoners often appearing almost unguarded but in no way desirous to escape; and as many Germans as British coming back along the same road.

E. The fifth point of interest, which I have touched on before was that, although it was invariably the enemy who inaugurated new forms of frightfulness and breaches of all known conventions, we were always able to pay him back in his own coin with something worse.

His was the first gas, ours is the most efficient. His were the first poison-shells, he is beaten at that game too. The only thing we have left him unquestionably master in, and of set purpose, are many atrocities. Everywhere else we can beat him.

F. A sixth point is the introduction into fighting of the new art of Mopping Up. When attacks are launched at trench systems, the fullest preparations have to be made for dealing with the attacking force in the back.

It is a comparatively new thing altogether, and certainly was in 1916. The III Corps suffered badly from the inhabitants of dugouts on July 1st: they were never caught again. The French made a fine art of it perhaps a little before we did: they had done so much more attacking than we on the western front. The art has come to stay, and is vitally important in trench and fortress warfare.

G. The seventh point I selected is the application of Mining to Field warfare. Although hitherto it has always been looked upon as a pure perquisite of fortress warfare, it was used last year while the line was quite mobile. We mined and blew up the German in High Wood at a time when they thought we could not possibly be undertaking such operations. They may happen again.

H. An eighth point of interest concerns the press correspondents. It struck me very forcibly that on the Somme the pressmen must have had extended facilities. I do not know if this was actually so; but one certainly met them in places very much further than one had been accustomed to, and in quite nasty corners.

The result showed itself in their writings; they had been allowed to see much more with their own eyes, and had had to get local effect so much less from others. So that what they write will probably be far more accurate than in the earlier days.

I remember in particular a statement in one journal, made in 1915, that all troops were taken up to the trenches by motorbus, to keep them fresh. It was credibly put before the British public that that was the case. At that time my own Division had had

a good deal of trench work, having been continuously in the line for a good period; and not one man in my own company had ever set eyes on one single motorbus, much less come anywhere near riding in it. We, and everybody else, walked up each time and each relief, and walked back again when our time "in" was up.

But there is very little of that nowadays. The correspondent of today sees with his own eyes; and from the places I have met them in, they see a good deal of the realities of the battle.

I. The ninth point, I have already gone into as a new feature, namely, our supremacy in the air. It remains perhaps to reiterate that this was due to one thing and one thing only—the superb bravery of our own pilots.

J. The tenth point is a brief one. It was remarkable what a degree of confidence our artillery, tanks, and other accessories produced in the attackilng infantry. Great attention was always paid to keeping the fighting troops always in the best possible condition before an assault; but, had the guns not shot straight, or had the Tanks proved a failure, all previous precautions might have been wasted.

The moral of it was that the more the infantryman knows is being done for him by the other branches, the better he succeeds in the attack.

K. The last point of interest I selected, was the excellence of the Administrative departments, Supplies, Stores, Engineering, and Medical.

The Medical Services in particular impressed all who saw them. Everything that could possibly be done was done for the wounded, and a good deal that was seemingly impossible. The nursing Sisters always seemed to call for special appreciation. They invariably appeared to work for most hours of the twenty-four somehow! Later on, when the casualty clearing stations had moved up in the wake of advancing troops, they were perforce under canvas, with possibly a few ordinary wooden huts as well. As the winter set in, the whole atmosphere was one of concentrated mud and wet. Add to that not infrequent aero-bombing by the enemy, and sometimes long range shelling by his big guns, and the situation was not ideal for a delicately brought up woman.

But they were always the same; equally cheerful and inspir-

ing of cheerfulness, whether one arrived as a battered hero in the middle of the morning, or as a most uninteresting sick case in the middle of the night.

I had said to me, coming under the latter category in the depth of mid-winter, "We're so sorry we can't make you more comfortable here, we're only under canvas. But you'll be all right when we get you back to a hospital."

The place would have been a Paradise after a few weeks in the front line. For the Sisters, accustomed to their homes, it was not. But they had no thought for themselves; only for their "Cases."

This excellence on the part of the Medical Services had a very great moral effect indeed on the men. When you are getting "slated" by the enemy and yet know that, if you are not killed outright, every possible conceivable thing will be done for you, it is a very different feeling to having any doubts on that score.

And the morale of the men was kept the higher accordingly.

7. *Now a few words about the results of the battle;* these were three, for all the objects were attained.

Firstly, the destruction of the Enemy's Forces in the Field. I cannot give the actual figures of German casualties, but they were enormous.

Our own were very great; but not in proportion, since we were the attackers. Moreover, it must be remembered that if the Germans and ourselves each lose one man, we are up on the deal, as our resources are greater than theirs.

Perhaps the best summary was a German communique, by wireless if I remember right, to the effect that the Allies had expended 100 Divisions to gain a paltry few square miles of ground.

It was substantially true. But it was countered at once, by the Allied statement, also true, that the Germans had expended the equivalent of 140 divisions to lose that same ground.

Napoleon was eventually beaten for lack of men. His troubles began at Moscow, and ended at Waterloo where he had an army of veterans and nothing behind them; he had called up too many classes before.

Germany has called up all her 1918 class, and has started on the 1919 one; and the same thing seems inevitable for her.

Secondly, the re-capturing of territory. On the Somme we did get back many square miles, worth perhaps twopence an acre free-

hold, it is true, but the sentiment is there. In the great Retreat which was the direct consequence of the Somme, we got back very appreciably more and better.

Thirdly and lastly, we got the initiative in the west, definitely and finally, as has been pointed out already. From now on, it is merely a question of what *we* are going to do; and not the enemy.

8. *The lessons of the Somme.* I have selected Eight, out of the eight hundred that might easily be found.

I. Rigid discipline and consummate obedience to orders are, if possible, more vitally important than even was stated to be the case before.

It is an unassailable fact that the more disciplined troops accomplished far more, fared better, and suffered far less, than the less disciplined ones.

II. The strictest attention to detail, even the minutest, is an essential to success in the field.

It is a military platitude that far-reaching disorder can arise from a deliberate error in one detail and instances did occur of this nature. General principles come first, and detail afterwards. But neither can stand without the other.

III. The policy of lead beats the policy of drive. The former is costly in officers, but, when these are killed, their men go on, following the lead of the next senior, because they are used to the policy.

In the German army, where the officers and non-commissioned officers drive their men, loss or slackening of the drive produced the inclination to stop or surrender. Moreover, it is far easier to overdrive than to overlead a man.

On one celebrated occasion, a battalion, brought from the Champagne front, surrendered entire: *i. e.*, the 700 survivors. We met them in Meaulte headed by 15 or 16 of their officers.

They had been driven into the line with insufficient rations and ammunition and almost negligible information, and told to retreive the battle.

They were a driven sacrifice, they knew it, and they knew of the High Priests sitting in comfort miles to eastward. Human nature would not stand it, and they surrendered.

Had they been not driven, but led, into the line by such offi-

cers as we can produce, we might have lost two men for every one of them.

Contrast that with our platoons who go on under a non-commissioned officer or a private when the rest of their leaders are killed; and it is a good weighing up of the policy of Lead versus the policy of Drive.

IV. On the Somme, the spirit of offensive was successfully inculcated into all ranks, even the lowest.

Once an attack was launched, it was followed up to the last degree. The result was that the enemy was never allowed any relaxation of the pressure, and could never form up successful counter attacks in any big degree.

The successes due to this were universal, and the lesson is to teach all ranks, when they do go, to go "all out," or, rather, to continue to teach them so, and to hold all they get.

V. All ranks must have a fair knowledge of simple field works. In consolidation this is vital, many successes or failures to hold ground won were decided simply by the fieldwork knowledge of the infantry concerned. It is merely an adaptation of the axiom that the Infantryman must be able to make his own cover. In practice, if well done, it reduces the casualties to an absolute minimum, and gives enormous confidence.

VI. Always go for a definite and limited objective, and when you have got what you have been told to get, stay and consolidate it until told to go on.

There were instances of quite large formations not heeding this, and getting involved or surrounded in consequence.

The ideal soldier will combine this judiciously with the lesson laid down as Number IV; for, in allotting objectives in unknown terrain, the higher Commands cannot legislate for all minor opportunities.

But the textbooks remain unaltered as to the forbidding of undertaking enterprises which may not only involve you unduly, but may involve other troops to get you out. And this lesson is a phase of that.

VII. In launching an attack, the coördination of all arms must be worked out to the smallest detail. Under coördination too, include its result, coöperation.

As far as practicable, each unit must know what neighboring units are doing and are to do, as also its own supporting units and branches of the service, guns, planes, etc.

Moreover, it is difficult to spend too much time in working out details of communication between the various troops. These days, when an infantry commander can signal, *via* his contact aeroplane back to his supporting heavy artillery, and get the particular point which is hanging him up knocked out within a matter of minutes almost, this has reached a very high degree already.

VIII, and lastly. There is only one way of getting a job of work done: whether it is the capturing of a country or the digging of a little hole.

On the Somme, officers and men alike from the highest to the lowest were given whatever they asked for to do their tasks, provided the requests were in all common sense.

Then they were judged by results, and by results alone. There was no time for ineffectual good intentions.

On the other hand, if a man made a reasonable request, and the necessary men, supplies, stores, materials, ammunition, or facilities, etc., were refused owing to some trifling technicality, or, still worse, some clerical objection, there was a very quick and effectual funeral not for the man, but for the refuser.

The whole campaign was managed in a spirit of trust, and never in one of deliberate mistrust.

The enghth lesson consolidates down to this: Trust your man and give him what he asks for. If you have trained him properly he will not betray your trust, neither will he ask for unnecessary things. Judge him by results alone; if he fails once through his own fault, dismiss him.

But if you or yours have trained him properly he will not fail.

All that was done on the Somme, and the officers and men did not fail.

ZONES OF SILENCE IN SOUND AREAS FROM EXPLOSIONS.

By

Charles E. Munroe

Professor of Chemistry, George Washington University.

The sound produced by an explosion may be communicated by waves transmitted through the air or through the earth, or both, depending on the location of the exploding charge. In investigating the testimony of witnesses, apparent confusion has arisen from the fact that persons near to an explosion center have stated that they heard no report while others farther distant in the same direction have stated that they heard it.

In his autobiography (*Hearst's* Magazine for December, 1917, page 444), Champ Clark states that as a boy of 12 years of age he was working on the Call farm, about 8 miles from Perryville, Ky., and says:

> One amazing fact about the battle of Perryville was that, while at a distance of 6 or 7 miles, I could hear it from beginning to end. General Buell and his staff, who were not half so far away, did not hear it until it had been raging 5 or 6 hours. Perhaps the topography of the country and the direction of the wind were the reasons for this phenomenon.

Again, Dr. H. W. Wiley reports that while ploughing in a field in Jefferson County, Ind., 200 miles from the battlefield of Fort Donelson, he and his father distinctly heard the great guns fired there.

The sounds heard by Clark from Perryville were chiefly transmitted by air and the conditions as to hearing them were somewhat analogous to those from fog signals which have been investigated by Henry, Tyndall, Livermore and others whose results are résuméd by Maj. William R. Livermore, Engineer Corps, U. S. A., in his "Report upon Fog-Signal Experiments."[1] The sounds heard by Wiley were undoubtedly transmitted by the earth, it being probable that there was on or near the farm on which Dr. Wiley was then ploughing an outcrop of the same rock formation as underlaid the battlefield at Fort Donelson. Such a condition, over a briefer dis-

[1]Report of the Light-House Board, 1894, Appendix No. 5.

tance, appeared to exist at Miller, where the nitroglycerin converter house of the Aetna Powder Co. was erected on the top of a sand dune, for, when this exploded, though the sound and shock appeared to be transmitted but a short distance through the air and was felt but slightly in buildings on the sand dunes, yet very severe effects were experienced in a town some 20 miles distant.

Under the title "Sound-Areas of Great Explosions," Charles Davidson, in *Nature* 98, 438-439, February 1, 1917, writing apropos of the results of the great explosion which occurred in London on January 19, 1917, says:

It is not often that a great explosion occurs near the center of a populous area, and the recent disaster in East London thus offers an opportunity of adding to our knowledge on the transmission of sound-waves by the atmosphere. A brief summary may first be given here of the results obtained in recent investigations. The most remarkable result is the recognition of the fact that there exists sometimes, not always, a zone of silence which separates two detached sound-areas. This zone has been traced in twenty recent explosions (excluding that of Friday, January 19th), two being due to gun-firing, four to explosions of dynamite or gunpowder, and the remainder to volcanic explosions in Japan.

The source of sound is always unsymmetrically placed within the inner sound-area, and nearly always lies on the side facing the outer sound-area. On this side the boundary of the inner area may be as near as 2½ miles, or as distant as 39 miles, from the source. The most important dimension, however, is the radius, or mean radius, of the curve which forms the outer boundary of the zone of silence. It is far from being constant. It may be as low as 50 miles, as with the minute-guns fired at Spithead on February 1, 1901, or as high as 99 miles, as with the Wiener-Neustadt explosion of 1912.

During the 4 years, 1909-13, eleven explosions of the volcano Asamayama, in central Japan, have given rise to double sound-areas, in most of which the outer area is the larger. The inner area is arranged with a rough approach to symmetry about the ash-precipitation zone. This is usually a long narrow band, the direction of which is determined by that of the higher air-currents into which the smoke-cloud from the volcano rises. The direction of the band is usually towards the east, but varies between north-east and south-east, and it is a significant fact that, as Prof. Omori has pointed out, the centre of the outer sound-area is usually on or close to the continuation westwards of the ash-precipitation zone. Of 22 important explosions of the Asamayama from December, 1909, to the end of 1913, Prof. Omori notices that single sound-areas occur just as frequently as double sound-areas. Nine of the former occurred in the 6 winter months, and ten of the latter in the 6 summer months. On the theory that the zone of silence is due to the refraction of the sound-rays by winds varying in velocity, and sometimes also in direction, with the altitude, Mr. S. Fujiwhara has shown that, with the normal type of winter

weather in Japan, the sound-areas would be single, and with that of summer weather, double.

With regard to the distance to which explosions may be heard, it would be well to separate those in which the sound-areas were single from those in which they were double. Of the first class, the explosion at Avigliana (northern Italy) in 1900 was heard at Lugano, 99 miles distant. The explosion in the same year at Kobe (southern Japan), which probably belongs to this class, was heard at 97 miles. Of explosions with double sound-areas, the distances are 90 miles for the Hayle (Cornwall) explosion of 1904, about 112 miles for the Förde (Westphalia) explosion of 1903 and the Jungfrau railway explosion of 1908, and 186 miles for the great explosion at Wiener Neustadt in 1912.

Though later accounts may modify some of the dimensions given below, a first analysis of the reports already received shows that the explosion in East London on January 19, belongs to the class with double sound-areas. The inner area is of unusual form, being L-shaped, with the angle near Godalming, the east-and-west limb reaching to Canterbury, and the north-and-south limb to the neighborhood of Northampton. The least distance of the boundary of the inner area from the source of sound is about 12 miles, and the greatest distance 65 miles.

The outer sound-area lies to the north of the other, with its centre a few miles west of King's Lynn. Its longer axis (131 miles in length) reaches from the neighborhood of Nottingham to that of Lowestoft, its width being about 55 miles. The zone of silence varies in width from 16 miles (near Northampton) to 54 miles, and the distance of its outer boundary from the source is about 60 miles. So far as is known at present, it includes the greater part of Essex and Suffolk, the southern half of the counties of Cambridge and Huntingdon, and the central portion of Northamptonshire. Even if observation should be received afterwards from this area, it is significant that, from the inner sound-area of about 3,500 square miles, I have so far received 250 records in which the time is given, from the outer sound-area of about 5,700 square miles 223 records (including 122 from Norfolk and 56 from Lincolnshire), and from the zone of silence of about 4,500 square miles only one, and that one close to the sea. The greatest distance to which the sound-waves penetrated is about 121 miles.

A remarkable feature about these records is that, though all of them have been sent in reply to my newspaper letters (and therefore sent as it were at random), they are almost as thickly grouped near the boundaries as near the centres of the two areas. There is none of that increasing sparseness of records near the boundary which is so characteristic of earthquake investigations. It would seem as if the boundary were determined, not by the sound-vibrations becoming inaudible, but by the absence of sound-vibrations from the area beyond. It may be of interest to add that, at a large number of places, pheasants showed signs of alarm, as they did during the North Sea battle of January 24, 1915.

Another feature in connection with these zones of silence in cases of explosion is found in the court testimony of eye-witnesses

who were near by the locality where an explosion had taken place, the implication on the part of the examining attorneys being that if no report was heard no explosion occurred. Because of the erratic behavior of explosives on exploding and the effect of obstacles and reflecting surfaces on the transmission of sound, no end of confusion may be introduced into an issue by attorneys who seek to becloud it. It is important that definite experiences regarding these events be placed on record, but as a rule there are so many startling incidents in various quarters occurring in connection with an accidental explosion and the participants are so frequently untrained in habits of observation that little reliable information is, as a rule, to be obtained from those who have been nearby and in the best position for observing. It is therefore with pleasure that I place on record the following account of personal observation and experience of an explosion of upward of 20,000 pounds of powder, within 130 feet distance from the point of observation, which was written out at my request by Mr. Charles H. Hudson, then Chief Engineer of the Southern Railway Co., some 20 years after the event and whose publication seems now opportune.

One summer afternoon in the year 1884 it was my fortune to reach Winchester, Ky., where I was to spend the night. The line of the Chesapeake and Ohio Railway passes through this little city in an easterly and westerly direction, some half or three-fourths of a mile from the center, or court house, for it is the shire town of the county. The Kentucky Central Railroad runs through the town, crossing the Chesapeake and Ohio very nearly at right angles, and at the station, which was joint to the two roads. They were at that time operated under the same management.

Upon the southerly side of the main line of the Chesapeake and Ohio, was a long side track, also crossing the Kentucky Central. Upon the westerly side of the K. C., in the same way, was a long siding, crossing the C. & O. main line and siding. In the south-western angle, formed by the two roads, was located a brick freight house, some 60 or 80 feet long, and facing the C. & O. track, with an 8-foot platform between it and the C. & O. siding. There was a platform of about the same width between the end, and the siding of the Kentucky Central. In the northwestern angle was situated a wooden passenger station and eating house, also facing the Chesapeake and Ohio, with a platform in front of it some 16 or 18 feet wide. A like platform was on the end next the Kentucky Central.

Upon this particular afternoon, there were three freight cars standing upon the siding of the Chesapeake and Ohio, the easterly end of which was some 60 or 80 feet from the crossing of the two roads. Some 20 or 30 feet westerly of the west end of these cars had been placed my car,

as I was then an official of the Chesapeake and Ohio Railway in charge of transportation matters. The easterly end of the car was thus some 180 or 200 feet from the Crossing.

In looking the yard over, in the course of the evening, I noticed a car loaded with 20,000 pounds or 800 kegs of blasting powder, and upon each side of the car was a large poster of white cloth, upon which was in very large letters, the word POWDER, with some other instructions as to the proper place in the train. It was so far distant from my car that there seemed to be no danger from it, so I thought no more of it.

At 6.50 the next morning, as I was sitting at my desk, awaiting my breakfast, I heard the long whistle of an approaching freight train from the east. A few minutes later I heard an urgent call for brakes which was repeated, and closely following the sharp exhausts of a reversed engine. As all trains should come to a stop before passing a railroad crossing, this seemed very unusual, and I hastily ran to the door, and to the north side of the car platform, looking at the same time in the direction of the approaching train. There I saw a string of freight cars upon the Kentucky Central siding across the Chesapeake and Ohio track, and right across that track was the large powder sign, while behind that powder car was the engine of the approaching C. & O. freight, still moving, with its nose under the powder car, which it had then lifted partly off its trucks, the engine wheels being in reverse motion, and the fire flying from the rails at a tremendous rate. While I realized the danger of the situation, curiosity or some other unknown power prevented my hastily leaving, as I should have done, and kept my eyes upon the powder car, which was instantly thrown upon its side and giving way before the locomotive, pushed as it was, by the heavier train behind. I heard only the crunching of the wood, as the car was broken to splinters, and I of course saw the kegs of powder roll out. Some 60 or 80 feet from the crossing, the car had been destroyed, and the train came to a stop, the engine, however still being in back motion, and still burning its wheels. While the powder was scattered all along, from a point perhaps 30 feet from the crossing, the bulk of it had been left piled up just in the rear of the tender, but largely upon the sides of the track. The first freight car of the train was standing over the piles. The engineer and fireman had jumped after reversing the engine. The conductor was upon the car next to the engine and over the piles of powder. The brakemen were upon cars further back, and had undoubtedly been setting brakes.

In the sketch herewith, Fig. 1, I have endeavored to show the situation as accurately as is possible after so many years, with no notes to work from. I made a very full report with maps showing locations made from measurements, but I am unable to find any copy of it, or notes pertaining to it. I feel quite sure, however, that this sketch is correct in the main, and will give a very correct idea of the situation and conditions.

All this had happened in a very short time, and now came the explosion, in which were consumed 785 kegs of the powder, or 19,625 pounds. I was still standing upon the platform of my car, at the spot marked A.

The detonation was so great that it was heard for 15 miles around, and yet I heard nothing but a buzzing sound, or a "whish," nor was anything more heard by those in the car. In the same way, I felt no concussion, and yet hundreds of windows in the village ½ or ¾ of a mile away had the glass mostly broken. The car over the piles was destroyed, and with the staves with which it was loaded was hurled into the air, and scattered in all directions. The car following was considerably damaged, and the car upon the siding close at hand injured and partly turned over. A considerable portion of the roof, including the overhang of the freight house was torn off, and the side and roof of the eating house was also somewhat injured, but not seriously.

The view that met my eye was a mass of flame much in the shape of a pineapple, about 25 or 30 feet high, with splinters, fragments, and fire filling the air for 60 or 80 feet higher (Fig. 2). In the middle of this mass of flame was the backing engine which was not derailed or injured, though a large hole was broken into the rear of its tender, the trucks of which, however, were still upon the rails.

With the explosion came the realization of the danger, and the thought of my two sons, who were with me in the car. I at once ran in to get them out of danger, and none too soon, for a large fragment of wood struck the car at the spot where a moment before I had stood. We got out at the rear end, running to the roadway, perhaps a hundred yards distant, when we realized that it was all passed and returned to the car.

Another officer of the Railway Co., who had charge of the track work, was in the eating house and, hearing the reversed engine, came to the door as the car was breaking and the powder began to roll out, and, being more sensible than I, at once fled through the eating house to a small flight of stairs, down which he was going when the explosion took place. He was thrown to the ground, but not injured. A number of others in that vicinity were thrown down by the concussion. The detonation was much more evident to them than to me.

This official reached my car at the same moment I returned to it, and we at once proceeded to see who had been hurt, and how much damage had been done. We found the engine still running (turning its wheels) in the back motion, and passed around the three cars to reach it upon the left-hand side. Just as we entered the engine, a colored man got up from the other side and shut off the steam.

We then found that only the conductor of the train crew had been hurt, he having been hurled some 80 or 100 feet and so terribly burned that he survived but a short time. A man who had been passing in the rear of the freight house, and about 100 feet or more away, had been so badly burned that he died, probably from some delayed explosion of the flying kegs.

The injury to the cars and buildings has been described. Two holes were found on either side of the track, something over a foot deep, evidently excavated by the explosion, while the track between the two was seriously injured, the rails not being in place and usable.

The fragments of the roof and broken cars were on fire, and we at

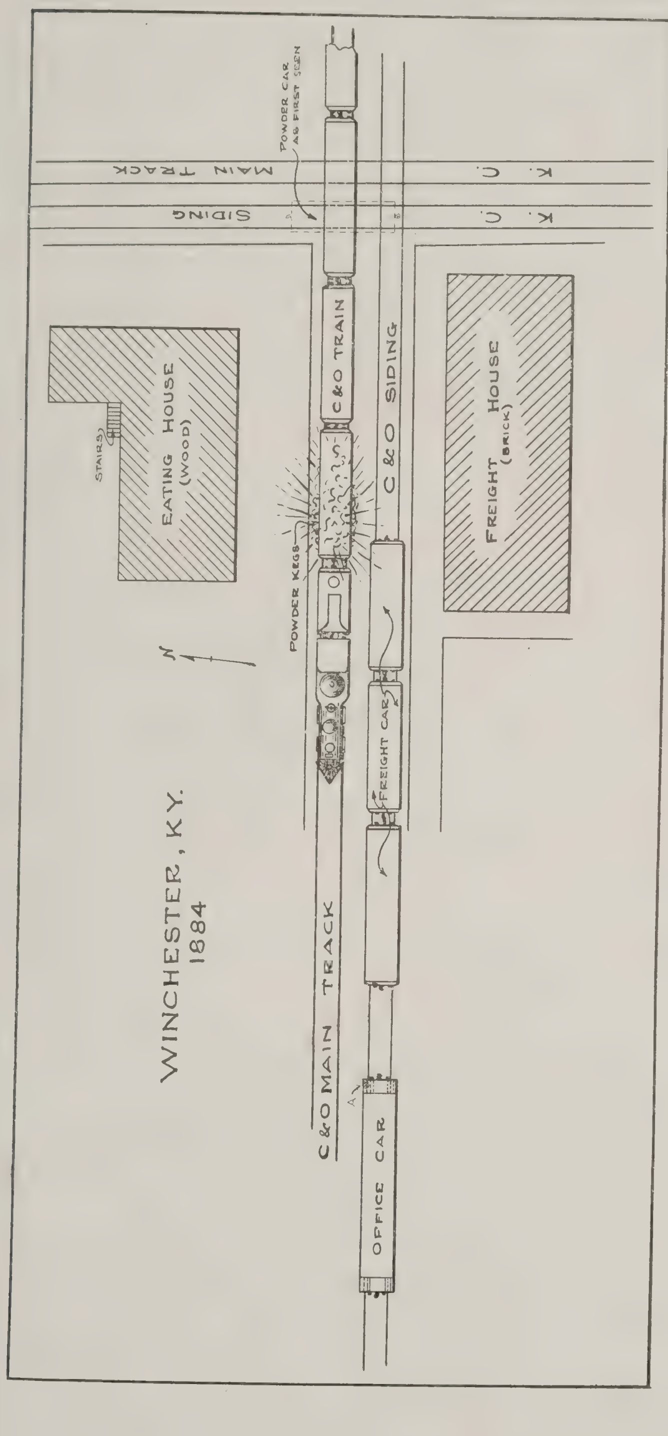

POWDER CAR AS FIRST SEEN
MAIN TRACK
SIDING
K. C.
K. C.
C&O TRAIN
C&O SIDING
EATING HOUSE (WOOD)
STAIRS
FREIGHT HOUSE (BRICK)
POWDER KEGS
N
FREIGHT CAR
WINCHESTER, KY.
1884
C&O MAIN TRACK
OFFICE CAR
A

Fig. 1.

once went to work, with such men as we could raise, to put this out, and clear the track for traffic. Smoke from nearby cars, with a cry of "powder," and the finding now and then of an unexploded keg, created some small panics among the men, but in about 30 minutes we had it all cleared up, and the fire out, and tracks ready for trains.

In our removals, we uncovered 15 kegs of unexploded powder, about half in one pile, and the rest scattered about. This was all that was left of the 200 kegs in the car.

The walls of the freight house were slightly but not materially injured. Those of the eating house were but little damaged.

Beside the sketch or plan of the situation, which I have prepared, I have added a cross section, showing the cars, and buildings, and also the view of the flame as it impressed itself upon my mind. I need not say

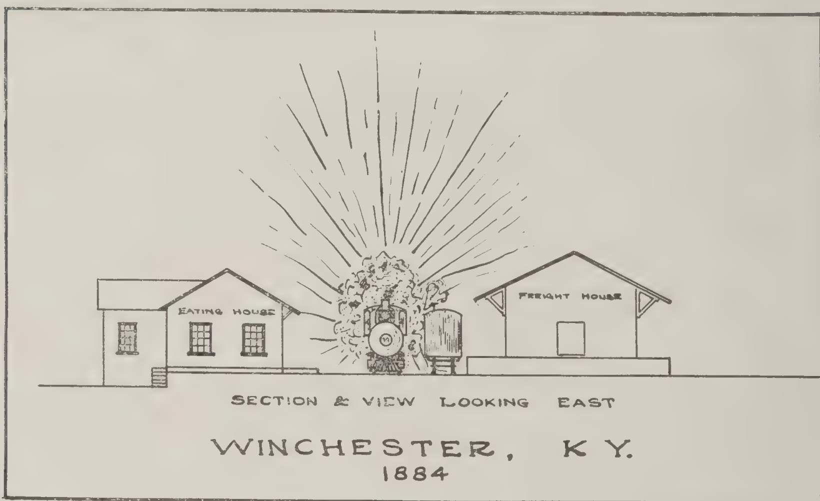


Fig. 2.

that the time for examining the view was very short, but I cannot easily forget the impressions made.

As before stated, we did not feel any concussion, nor did we hear more than a buzzing sound, or "whish," although only perhaps 120 or 130 feet away. I cannot explain this, unless it be that the engine, immediately in front of the center of the explosion, or between it and my car, with the cars and buildings alongside and in close proximity of the engine, prevented the motion of the air in that direction to any great extent, but caused its direction to be upward.

The motion of the upper air seemed to pass over us, as is evidenced by the breaking of the windows $3/4$ of a mile away, and the hearing of the detonation upwards of 15 miles away.

C. H. Hudson,
Knoxville, Tenn.

Aug. 6, 1904.

Note: Professor Munroe is still investigating the phenomena of "zones of silence in sound areas from explosions," and it is hoped that he may soon prepare another paper upon this subject.

MILITARY SEARCHLIGHTS.

By

Lieut. Roger Haydock
Engineer Officers Reserve Corps

Warfare has been largely responsible for the development of the searchlight. During the past fifty years, it has been used by the army and navy, but mainly in a defensive way. At first, the army used it in connection with permanent fortifications, for a methodical exploration of the surrounding terrain at night in order to disclose any hostile movements of the enemy. Coast defenses also used searchlights to locate an enemy craft and hold it in view so that effective fire could be brought to bear upon it. Conversely the navy used them to locate hostile coast fortifications, ships, mines, etc. These lights, however, were not as a rule mobile, they were fixed a part of the fortification or of the ship. Later, as military science developed, it became necessary to bring the searchlight up to the front; there it has played an important rôle—being used to discover artillery, machine guns and riflemen of the enemy, and give its friendly troops a good target. Then came the advent of the military aircraft; to combat these the searchlight has been developed in giant strides, until now, according to the most modern authorities, we have the military searchlights divided into the following groups:

(*a*) The searchlights of position, whose caliber ranges from 90 cm. upward, (*b*) the field searchlight, mobile and light, of medium power (about 60 cm.), particularly adaptable for field operations, and finally (*c*) the trench searchlight which, as the name implies, is used to illuminate the immediate foreground and obstacles of the trenches. They, of course, must be very light and mobile in order to insure their quick and easy transportation; the caliber of these lights ranges from 25 to 40 cm.

As the mobile type developed various other missions were assigned to the searchlight, many of which were of an offensive

nature, such as using it to blind the enemy and thereby contribute to his demoralization and impair the efficiency of his fire. Then we have it used to combat the enemy searchlights by flashing his troops with beams from the right or left, nullifying the effect of his searchlights.

The searchlights also play an important part in signalling, in strategy and deceptions, the limitations of which are far reaching and depend only upon the ingenuity of the officer in charge.

The control of the field searchlights and those of position are in the hands of the zone or section commanders. The local commander has charge of the lights of smaller caliber.

The application of the flame electrode brought out in the recent developments has produced a notable advance in the performance of the searchlight. The old type has given way to the modern high current density arc with small crater, producing a much higher intrinsic brilliancy and beam intensity. The use of the small carbons also produces less "shadow" or dead space on the mirror, which consequently increases the efficiency of the lamp. Care must be taken, however, not to make this reduction too great, nor to carry the current density too high, since the tip of the electrode will oxidize or "spindle," causing a reduction of the diameter which affects the brilliancy.

As has been said, the small mobile searchlight of medium power is used in field operations. The aim in design being to keep down the weight, so as to allow rapid, easy transportation. The automobile offers the most advantageous means of effecting this transportation of the searchlight, and has now been adopted as a standard form for "semi-mobile" lights, "semi-mobile" since they are dependent upon the condition of the roads and terrain. The horse-drawn searchlight is far more mobile, but not nearly so fast, when road conditions are good.

As the Italian Army has been actively engaged in developing the searchlight, a short account of their work as shown in the catalogue of the Fabbrica Italiana Automobili Torino may be of general interest. It is understood that this type has been successfully used by the Italian Army.

CHASSIS.

Engine. The engine is of the vertical 4-cylinder type, of a power of 30 HP. The cylinders are cast in 1 piece (monobloc system) with the water jackets. The base is of aluminum. The valves are

interchangeable, placed on one side of the engine and completely cased in by a cover which can be removed easily when required. The connecting rods are of stamped steel; the pistons of cast iron and the crank shaft of forged steel running in 3 bronze bearings lined with white metal.

Fig. 1.

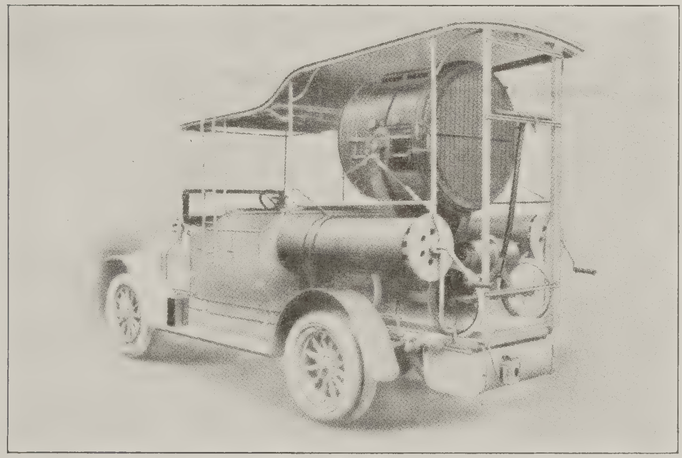


Fig. 2.

Lubrification. Forced feed lubrification is provided by means of a geared pump, driven directly by the camshaft.

Ignition. The ignition is by Bosch High Tension Magneto, with advance operated by a hand lever.

Carburettor. The carburettor is of the constant level spray type with 2 jets.

Cooling. The cooling is effected by means of a centrifugal pump though a radiator of the honeycomb type and its efficiency is further increased by the action of the fly-wheel fan drawing air through the radiator.

Clutch. Multiple disc type with sheet steel discs and spring, ensuring perfect contact of the 2 sets of discs, perfectly protected.

Change Speed. The change speed is of the triple sliding type with direct drive on top speed and reverse. Speed changes are effected by fork levers attached to the operating rods, the reverse being fitted with a security catch. The gears are made of nickel steel and the gearshafts of chrome nickel steel.

Transmission. The transmission is by cardan shaft of the single universal joint type. The live axle casing is of stamped steel made in the shape of a ''T''; the cardan shaft runs on enclosed ball bearings and is enclosed in the longitudinal arm of the ''T'' shaped casing, whilst the differential shafts are contained in the transverse arms of the casing.

Steering. The steering is of the worm and segment type, and is fitted with a throttle hand lever with another lever for the ignition.

Brakes. Two very powerful brakes are fitted, which are constructed to act when the car is going backwards or forwards. The foot brake is operated by a pedal and works on the transmission shaft. The side brake is actuated by a hand lever and works on drums fitted to the back wheels.

Frame. The frame is of stamped steel attached to the axles by means of springs made of manganese steel. The wheels are made of wood, fitted with Michelin detachable tires, of a special type for heavy cars. The front wheels are fitted with single tires, the back wheels with twin tires.

DYNAMO.

Dynamo. The dynamo is of the closed-in type and produces a direct continuous current of 100 amperes at 80 volts. It is fitted parallel with the axle of the vehicle, over the change speed and is operated by the coupling shaft through the 2 toothed wheels and a silent chain. Armour in extra sweet steel, shut at the ends by means of 2 walls carrying the bearings of the shaft with ring lubrication. Aerification of the collector by means of a little fan mounted on the axle of the induct. Polar expansions in laminated iron; induct at drum shape, with collector made of electrolitic copper sections, insulated with mica; graphitic coal brushes, easily changeable.

An Electro Magnetic Control is fitted acting on the carburettor so as to obviate variations in the number of revolutions of the motor, whether the projector is working or not. A switch board is also fitted with voltmeter and regulator of the magnetic field.

BODY.

The body is of the open type with 6 seats, 3 of which are in the front and are protected by a windscreen, and 3 in the middle of the car with space at the back available for the projector. A canopy is fitted supported on 8 columns in plain iron raised at the back by 30 mm., and fitted with waterproof curtains. A rail is fitted at the back for removing the carriage of the projector out of the car. A luggage rail is fitted on the canopy at the front with ladder for reaching same. Double-folding screen. Four side doors, 3 sliding and 1 fixed. Three back doors, 2 at the sides of the projector; the one at the back can be dismounted easily. A door is also fitted at the side of the dynamo. The body wings are

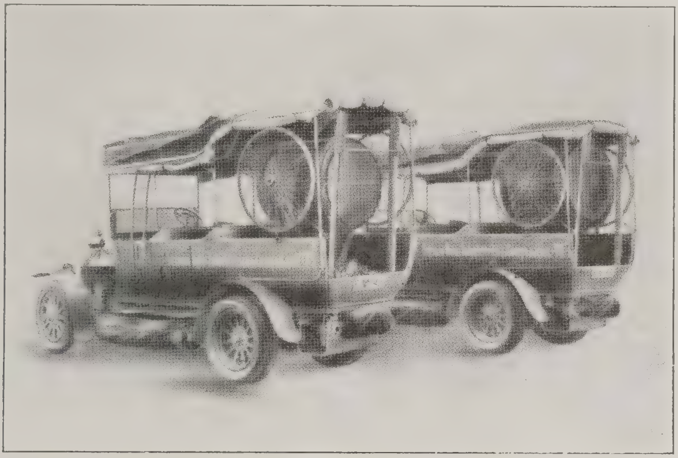


Fig. 3.

of sheet steel with valances. Two head lamps, side lamps, tail lamp and horn are also supplied.

SEARCHLIGHT.

Stand. The stand is very low, resting on the ground by means of 4 legs folding on the inside and supporting externally the safety fuses, the couplings which connect the electric motors for revolving the searchlight, the terminals for the current, the device for controlling at a distance and the 2 screwed tubes that support the same. On the upper portion are fitted rings to carry the current to the projector. For travelling Stations, a wooden baseplate reinforced with iron liners so that the searchlight stand can be fixed firmly on soft ground.

Platform. The platform of the searchlight moves on the ball bearings and carries the collecting brushes for the electric current. The movements of this platform are effected by hand either acting directly on the searchlight supports, or by means of a hand-

wheel acting on a speed reduction mechanism. One of the supports carries a voltmeter and a rheostat and the other a rheostat automatically reducing the current at the closing of the iris.

Searchlight and Fittings. The searchlight consists of—

(1) A glass parabolic mirror fitted to the frame which can be easily removed; it is artificially cooled by a small electric fan, thus guaranteeing a long life.

(2) Electric lamp with automatic or by hand controlling device. The carbon holders can be dismounted easily in order to quickly change the carbons. Arrangements are fitted for the observation of the arclight on a screen in 2 directions at right angles. The positive carbon holder may be rectified from outside.

(3) An "Iris" shutter, that can be dismounted easily and can be operated either by hand or by motor with an automatic switch for reducing the intensity of the current of the arc so as to avoid excessive heat, if the shutter is closed. External protection of the shutter is given by flat glass cut in sectors and elastically mounted, in order to avoid breakage by heat.

(4) Blind signal apparatus, constituted by a series of parallel aluminium plates, which move together controlled by a lever and permit of the entire shutting off of the light for signaling purposes. The electric searchlight which has been adopted for these cars has been specially designed in order to obtain a very simple control at long distance without interfering with the safety of the car and without any loss to the advantages obtained from hand projectors. For the changing and controlling at distance of the direction of the rays, 2 small electric motors are arranged in a box which can be dismounted in a few seconds without the use of tools. Another small motor of the closed type is fitted on the outside for controlling the movement of the "Iris" shutter. The motors are connected by means of a light flexible cable (120 metres is generally sufficient) to a controlling box of the approximate weight of 1.200 grs. This mechanism is actuated by the operator who is thus at liberty to regulate the movements of the shutter as well as of the searchlight, either continuously or at short intervals.

The electric current is led from the dynamo to the projector by means of a cable weighing 0.900 kg. per linear metre coiled on two rollers which are supported on ball bearings.

The projector is further supplied with a small carriage fitted with wheels and rollers so that it can easily be dismounted.

The rollers or beams facilitate the sliding of the projector on rails which can be extended to the outside of the car, and 2 wheels fitted with rubber tires serve to transport the carriage by hand on land.

The plant is finally completed by 2 portable microtelephonic stations, 200 metres of cable coiled on a roller which is fixed at the back of the car. The projector of 90 cm. is practically the most powerful projector which would be capable of easy trans-

port. With the foregoing apparatus it can safely be asserted that a large body of troops could easily be discovered at night at almost the same distance as it could be done by day, while at the same time, the greatest invisibility is obtained in the darkest night at only a few yards distance, with the iris shut and the searchlight working. The care and working of the apparatus is of the greatest facility and simplicity.

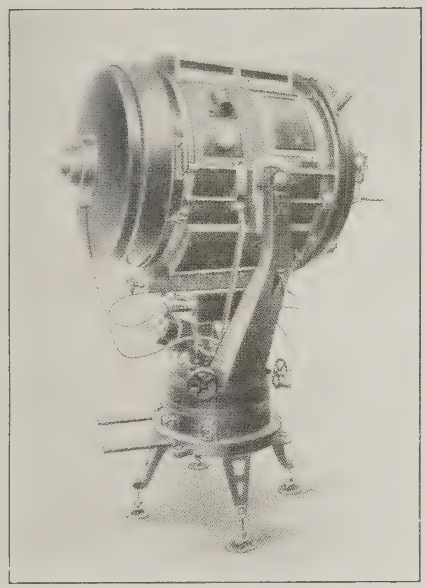


Fig. 4.

Fig. 6.

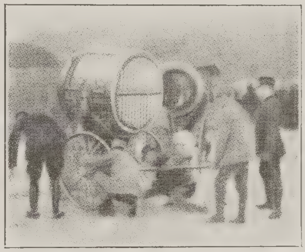


Fig. 7.

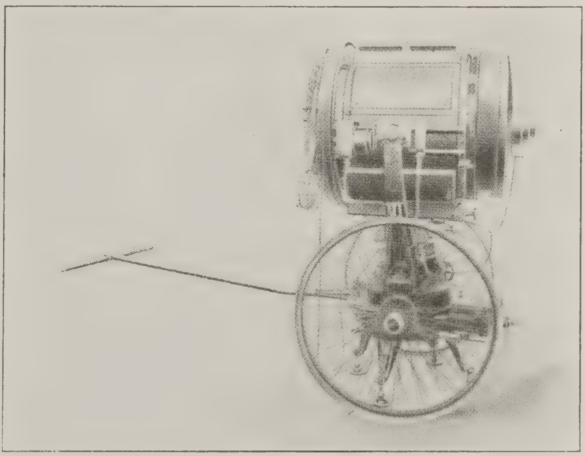


Fig. 5.

EDITORIAL NOTE.

The Chapters on "Tactics and Duties for Trench Fighting," by Captains Solbert and Bertrand, which appeared in the last two numbers of the MEMOIRS, have been copyrighted and published by Messrs. G. P. Putnam's Sons, through whose courtesy another chapter is to appear in the next issue.

Erratum.

In Vol. X, No. 49: On maps on pages 22, 24, 26 and 28, instead of Yula read Yalu.

GENERAL THOMAS HOWARD RUGER

FROM A PORTRAIT IN POSSESSION OF THE MILITARY SERVICE INSTITUTION, GOVERNORS ISLAND, NEW YORK

NEW YORK CITY'S CATSKILL MOUNTAIN WATER SUPPLY[1]

By

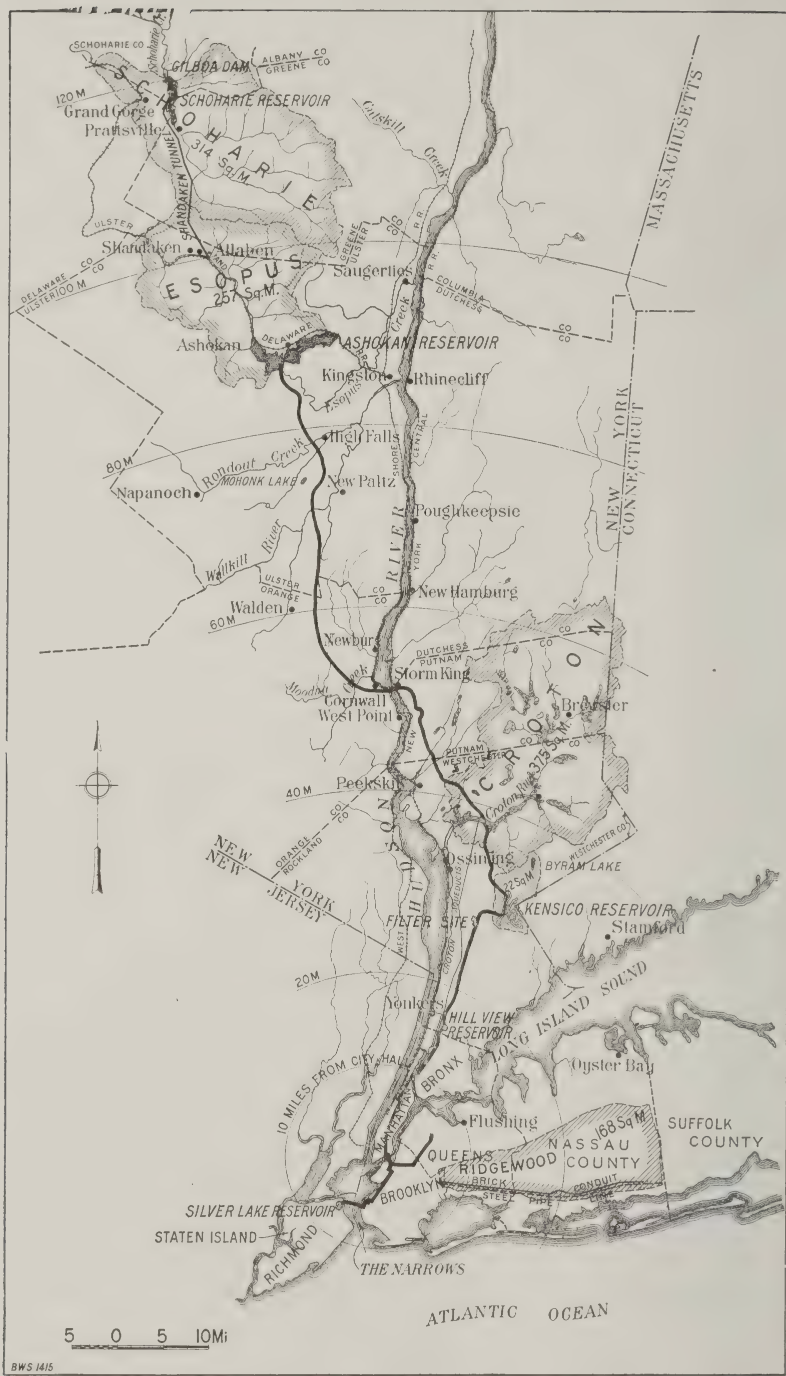
Mr. Alfred D. Flinn
Deputy Chief Engineer, Board of Water Supply
New York City

Until Catskill Mountain water became available, supplies for Manhattan and Bronx boroughs were obtained principally from the Croton River, first put into use in 1842; for Brooklyn, from wells and ponds in Nassau County, Long Island, and for Queens and Richmond boroughs, from local wells mostly owned and operated by private water companies. Due to occupation of water-gathering grounds by growing communities, some smaller sources of supply became unsatisfactory. Existing systems have been outgrown, although the more important ones will be used permanently.

Of recent years New York City's population has been increasing at the rate of about 157,000 persons each year—the equivalent of Atlanta, Hartford, or New Haven; or every three years as many people as there are in Buffalo; in four years enough persons to populate the state of Rhode Island. For each additional person approximately 100 gallons more water are required each day. Consequently, from time to time, extensive additions to the city's water supplies have been, and will continue to be, necessary. The Catskill system, the first and most important portion of which has recently been put into service, is the greatest addition ever made to any city's water resources. The second portion of this Catskill scheme, to be completed in about seven or eight years, will add an equal quantity of water. At a somewhat more distant future, if the city continues to grow, other supplies must be sought and developed.

Assuming that sufficient reasons have been advanced for additional supply of water, attention is invited to the new Catskill Mountain system constructed by the Board of Water Supply—

[1]Presented before the Worcester Tech Club, at the Engineers' Club, January 3, 1918; reprinted, by permission, from *The Journal of the Engineers' Club of Philadelphia* (and Affiliated Societies), March, 1918.



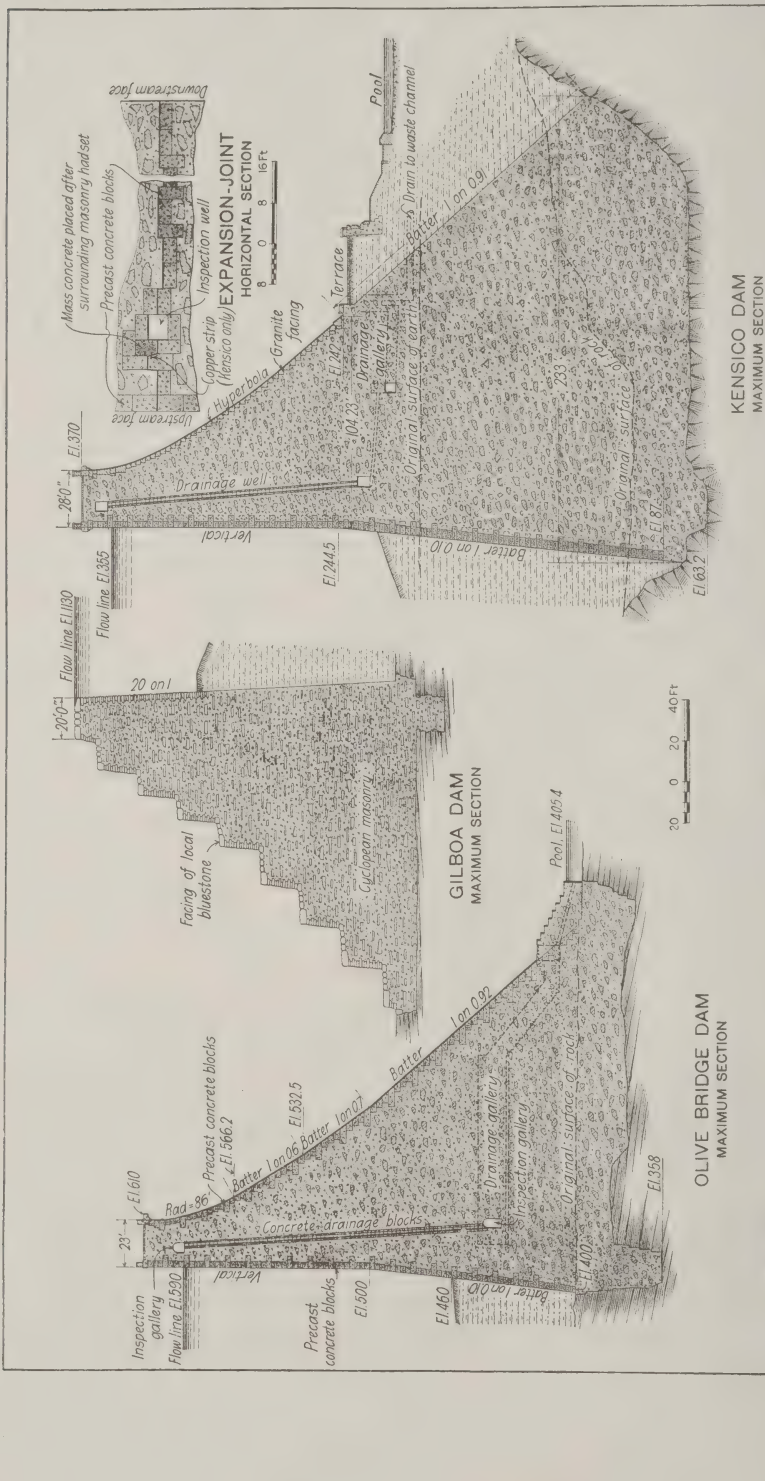
Map of the Catskill Mountain Water System, showing its relation to the Croton and Ridgewood Systems.

to its sources, to works for collecting water and conducting it to the city, and incidentally to some of the engineering problems. Description of the works will be prefaced by a

BRIEF OUTLINE OF THE SYSTEM.

For legal and engineering reasons, streams west of the Hudson River, in the Catskill Mountains, were chosen as the most available, economical, and best sources. It was determined that the new system should furnish as a year-in-and-year-out average 500,000,000 gallons of water daily. As a matter of engineering judgment, an aqueduct of this capacity was deemed as large as could be built in the region to be traversed, and no less an increment should be made to the city's water resources. This quantity of water, flowing through a fifty-foot wide street at a velocity equivalent to an average walking speed, would make a stream shoulder deep. It was found that half the desired quantity could be procured from Esopus Creek, above Olive Bridge, and the other half from Schoharie Creek, above Gilboa, the areas of these watersheds being, respectively, 257 and 314 square miles. It was decided to develop Esopus Creek first. To secure the quantity of water required daily it is necessary to conserve flood flow. For this purpose Ashokan reservoir has been created ten miles west of Kingston, three-fifths of its capacity for Esopus water and two-fifths for Schoharie. For the remaining storage needed for Schoharie Creek a reservoir is to be constructed in the immediate future. From this reservoir, Shandaken tunnel, 18 miles long, 11 feet 6 inches high, and 10 feet 3 inches wide inside, of 650,000,000 gallons daily capacity, piercing the intervening mountains, will convey the water into Esopus Creek, eleven miles above the western extremity of Ashokan reservoir.

Catskill aqueduct begins at Ashokan reservoir and extends 120 miles to Staten Island, a three-day journey for the water, crossing the Hudson 3½ miles above West Point and having a branch, seven miles long, from the heart of Brooklyn to Queens Borough. With so long an aqueduct it is necessary to maintain a large store of water near the city. A natural basin was found at Valhalla, three miles above White Plains, and here Kensico reservoir has been created for this purpose. To equalize the constantly fluctuating demands against the steady flow in the aqueduct, a small reservoir was needed on ground of sufficient elevation close to the city. In Yonkers, just north of the city line, a suitable hill was dis-



Cross-sections of the principal masonry dams of the Catskill Mountain waterworks. Flood waters will flow over the top of the Gilboa dam, but not over Olive bridge nor Kensico dam.

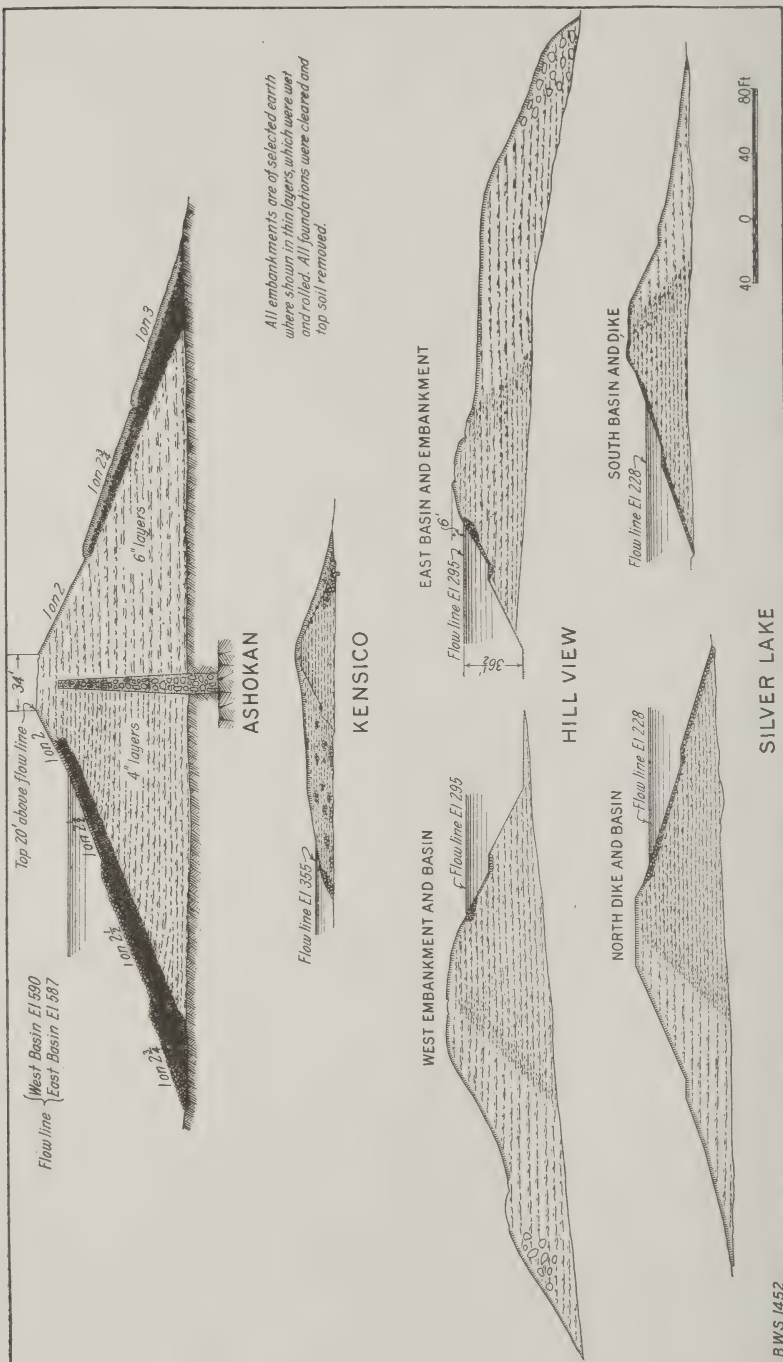
covered, and on its top Hill View reservoir has been constructed. Fifth and last is a small terminal reservoir on Staten Island, known as Silver Lake.

TYPES OF STRUCTURES.

The major dams at Gilboa, Olive Bridge, and Kensico are of masonry. The configuration of the valley at Gilboa is such that the surplus water of floods must be discharged over the main dam which, consequently, will have its crest at full-reservoir level and its downstream face built in steps to break the falling water. Because at Ashokan floods can be more conveniently cared for otherwise, and at Kensico the reservoir can be completely controlled by manipulation of the flow from the aqueduct, no water will pass over the main dams. Each carries a highway. Olive Bridge dam is 23 feet thick at its thinnest part; Kensico, 28 feet. The former has a maximum height of 240 feet and the latter 307 feet, with maximum thickness at the bottom, respectively, 190 and 235 feet.

At Ashokan, to extend the main masonry dam and to fill natural gaps in the sides of the reservoir, about five miles of earth dams, or dikes, were required, attaining a maximum height of 120 feet. These were built of selected fine earth in thin layers, thoroughly compacted by rolling, and have substantial core-walls of concrete, founded in rock or very impervious hardpan. These dikes are covered with grass on their tops and downstream slopes and with stone riprap and paving on the water slopes. Kensico reservoir required but a minor dike, made of liberal dimensions to utilize earth from excavations for other structures. At Hill View and Silver Lake large quantities of earth from the basins had to be disposed of, and the embankments were made of generous cross-section, only a portion being of selected earth in thin layers. At the last three reservoirs the dikes were shaped partially to resemble natural hills, and, because of great thickness, have no core-walls.

To dispose of floods occurring when Ashokan reservoir is full, a concrete waste weir, 1000 feet long, and a paved channel were constructed at a place whence the water could be safely conducted into Esopus Creek, three miles downstream from the main dam. For many reasons connected with the control of the reservoir, it was desirable to divide this great artificial lake into two basins. By extending a weir and dike from a hill jutting into the north side of the valley to the Beaverkill dikes, closing a long gap

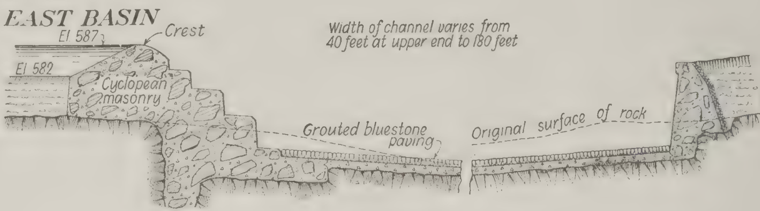


Cross-sections of earth dams, or dikes, of the various Catskill Mountain water supply reservoirs.

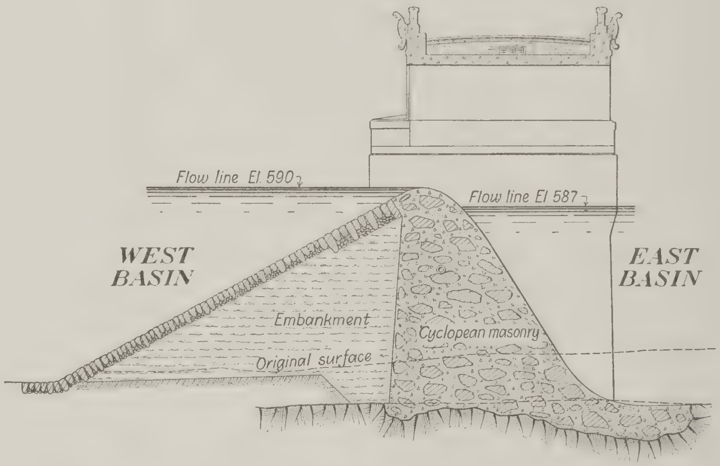
in the south side, this was readily accomplished. Opportunity was thus afforded to carry a highway across the reservoir by building a bridge on the dividing weir. For Kensico reservoir a waste weir only 50 feet long was provided, more as a concession to sentiment than to meet any real need.

Catskill aqueduct traverses a much diversified country. There are gentle hillsides and broad plains at suitable elevations along which cut-and-cover aqueducts could be constructed, in which the water flows without being under pressure; but there are hills and mountains which had to be pierced with grade tunnels, so-called, at the flowing level of the aqueduct. Many valleys, some of them wide and deep, have to be crossed. For fourteen minor valleys, riveted steel pipes were adopted, some 9 feet and others 11 feet in diameter. In each valley three pipes will be required for the full capacity of the aqueduct, although but one has yet been laid. For protection from rusting and to make the smoothest possible interiors by covering the rivet heads and the laps of the steel plates, these pipes were jacketed with concrete and lined with Portland cement mortar. At each side of each valley a chamber containing sluice gates connects the pipes with the adjoining aqueduct.

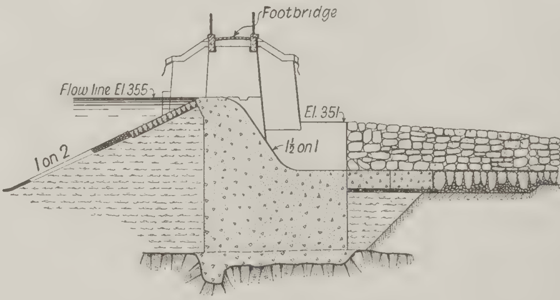
Few engineering problems required more thorough and protracted study, more boldness of design and execution, and more ingenuity than the crossings of the Rondout, Wallkill, Hudson, and Croton valleys. For economy, permanence, and security, it was decided to use circular tunnels in the rock. As the gorges originally occupied by the streams are far below their present channels, these tunnels were forced to great depths, in order to keep in rock. In them the water is under high pressure; therefore they were named pressure tunnels. For 2½ miles north of Hill View reservoir, also, the aqueduct is of this type and known as the Yonkers pressure tunnel. The largest pressure tunnel is 16 feet 7 inches and the smallest 11 feet in diameter. They are lined with concrete to improve their hydraulic properties and aid in rendering the surrounding rock more watertight by means of grouting; that is, injecting thin mixtures of cement and water into the crevices under high pressure. Each pressure tunnel has a downtake shaft at one end and an uptake shaft at the other. For the longer tunnels several intermediate shafts were required to expedite construction, which were sealed at completion of the work. Provision was made for unwatering whenever it should become necessary to enter a tunnel for inspection, cleaning, or re-



ASHOKAN WASTE WEIR AND SPILLWAY
Crest length 990ft.



ASHOKAN DIVIDING WEIR AND BRIDGE
Crest length 1000ft



KENSICO WASTE WEIR
Maximum section
Crest length 50ft

0 2 6 10 14 18 22 Ft

BWS 1451

pairs. For this purpose there is a drainage shaft, in which can be placed special pumping apparatus in a cylindrical boat or float. The drainage shaft is 75 feet from the tunnel, but connected by a drift, flow through which is prevented, when the tunnel is in service, by a special valve. Each drainage shaft has a superstructure, of the type shown in the illustration. Exceptions became necessary at Hudson River and Croton Lake, where waterway shafts were so constructed that they could be used for drainage; Yonkers tunnel can be drained, without pumping, through the Bryn Mawr steel pipe, which connects with its north end under pressure, by means of a blow-off.

A pressure tunnel was adopted for delivering the water in New York City instead of laying a great number of large pipes in the streets, with the accompanying intolerable annoyance. This tunnel secured many advantages and accomplished a saving of $15,000,000 as compared with pipe lines. It is by far the longest tunnel in the world, being almost 18 miles in length.

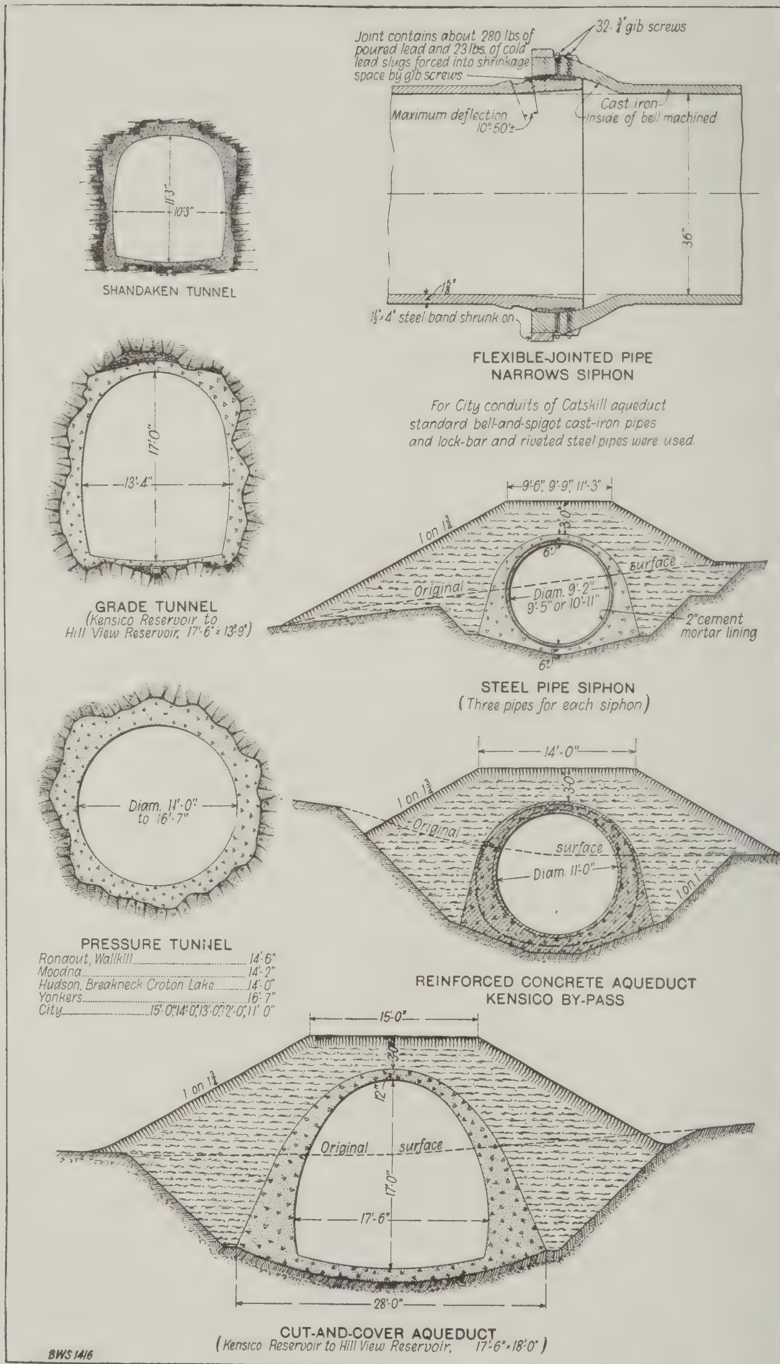
At a few places where the aqueduct when in use would be under only slight pressure it was built of concrete, heavily reinforced with steel rods.

To get Catskill water to Staten Island, the most formidable barrier of all had to be negotiated; namely, the Narrows of New York Harbor, with all the difficulties of great depth of water, wind, tide, fog, and heavy traffic. For this crossing an improved type of ball-and-socket cast-iron pipe, 3 feet in diameter, was devised.

The size of the cut-and-cover conduit is apprehended when compared with a railway car, and its relation to other aqueducts in cross-section is shown by drawing them side by side to the same scale.

SURVEYS.

Although the topographic maps of the United States Geological Survey covered the region, and a few detail maps had been made by predecessors of the Board of Water Supply, it was still necessary, in order to determine the most suitable exact locations for the aqueduct, the reservoirs, and their appurtenant structures, to run about 3,000 miles of line surveys, take topography of tens of thousands of acres, dig hundreds of test pits and drill thousands of holes into the earth, aggregating, if put end to end, 45 miles in depth. Through winter's snows and summer's



SHANDAKEN TUNNEL

FLEXIBLE-JOINTED PIPE NARROWS SIPHON

GRADE TUNNEL
(Kensico Reservoir to Hill View Reservoir, 17'-6" × 13'-9")

STEEL PIPE SIPHON
(Three pipes for each siphon)

PRESSURE TUNNEL

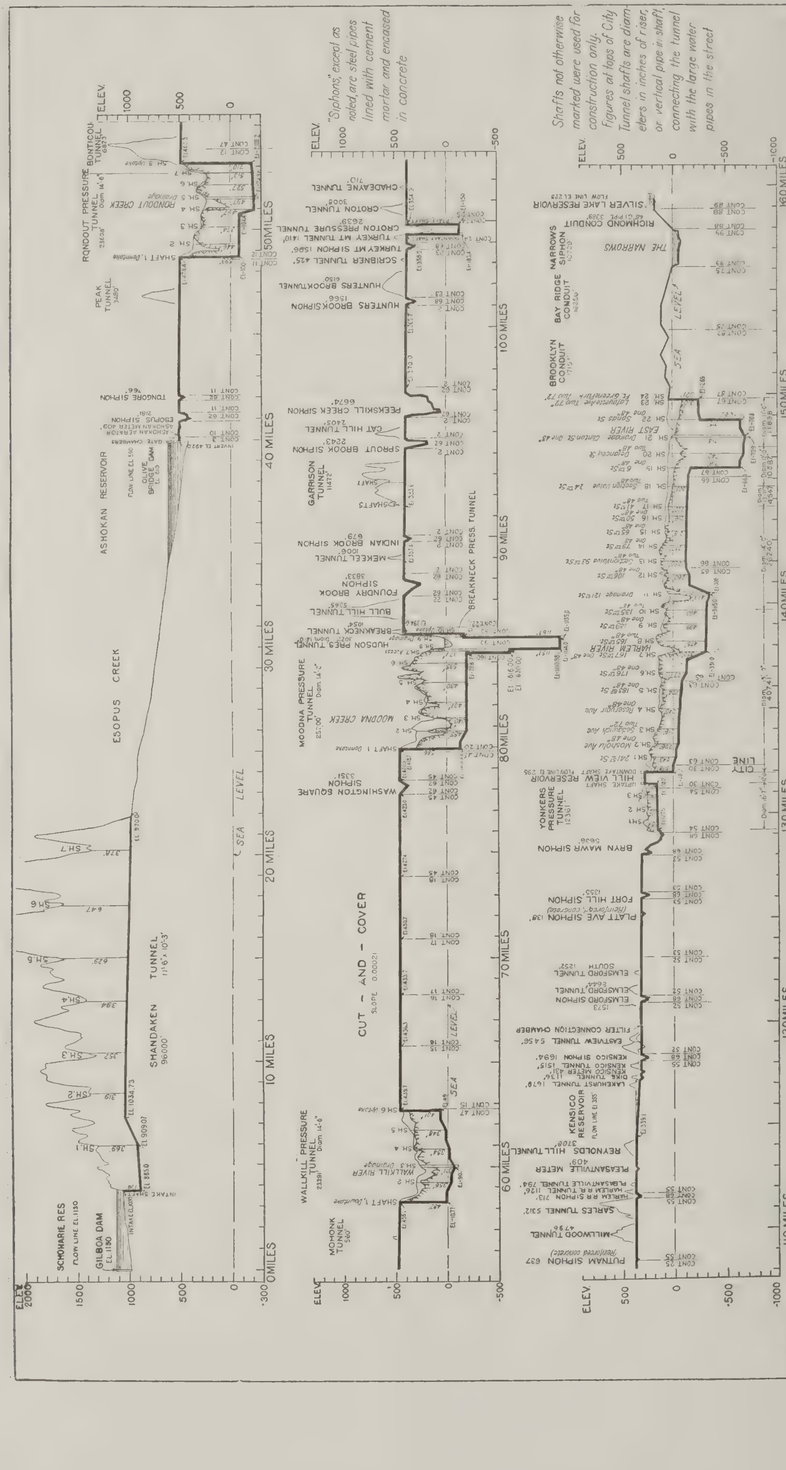
REINFORCED CONCRETE AQUEDUCT KENSICO BY-PASS

CUT-AND-COVER AQUEDUCT
(Kensico Reservoir to Hill View Reservoir, 17'-6" × 18'-0")

heat, across frozen rivers and up rocky precipices, these surveys were pushed.

At Olive Bridge and all other dam sites, along the aqueduct, particularly at tunnel locations, and in the city streets, wash and diamond drill borings were made under the guidance of engineers and geologists to learn the nature of the ground to be excavated, the depth to rock, and its character. This information was needed, so that the most appropriate type of structure might be selected, economically located, and intelligently designed; so that many problems might be solved in advance, and so that contractors, having ample knowledge of conditions, might safely make lower bids for construction. Similar explorations were made for quarries and sand pits. By means of diamond and shot drills, cylindrical cores of rock were obtained, varying from 3/4 inch to 5 inches in diameter and from a fraction of an inch to 10 feet in length. Carefully selected cores, sufficient to show the character of all the rocks investigated, have been fully labeled and systematically deposited in places of safe keeping in the city and along the aqueduct so that they may be available for further study in connection with future water supply or other projects or for the advancement of the geological knowledge of the region.

Of all the geological explorations, the most difficult, the most tedious, and yet the most interesting was the search for a Hudson River crossing. Bridges, submerged pipes and other suggestions were rejected in favor of pressure tunnel because of the great economy of the latter and its superiority in other respects. Supplementing extensive surface examinations of the regional geology, drillings were made across the river, between Poughkeepsie and West Point, at six places which seemed to have possibilities, choice finally falling on the northerly gate of the Highlands, where a gneissoid granite forms Storm King Mountain on the west, Breakneck Ridge on the east, and the bed of the river. The depth to rock in the pre-glacial gorge had to be learned. Many endeavors were made to determine points on the rock surface by drilling from a number of scows anchored in the river, but the tide, storms, and traffic, as well as the depth and nature of the glacial filling of the gorge, made progress slow and uncertain. At a few points near shore rock surface was reached, and ultimately a drill in the middle of the river attained a depth of 768 feet, but without encountering rock, before it was swept from its location by a colliding tow of barges.



Profile of Catskill Mountain water supply system from Gilboa dam to Silver Lake terminal reservoir, showing the elevations of the reservoirs and of the different parts of the aqueduct.

To obtain more complete and dependable information, in February, 1907, the Board began sinking a test shaft on each margin of the river. Two hundred and fifty feet below the river surface a chamber was excavated in each shaft, and diamond drill borings inclined 45 degrees were started toward the middle of the valley. These attained a depth of 1,500 feet, having yielded excellent samples of rock throughout their lengths of approximately 2000 feet. Next a pair of holes at half this inclination was undertaken in the anticipation that they might pierce the gorge surface. Instead, they continued in rock to an intersection 950 feet below river level. It being unnecessary to pursue the investigations further, the tunnel was located at the minimum required depth in sound rock (150 feet) below the intersection of the second pair of drill holes; *i. e.*, 1100 feet below the river surface. Meanwhile, shaft sinking had been continued and in March, 1911, reached the predetermined depth for the tunnel, having continued in suitable rock from top to bottom.

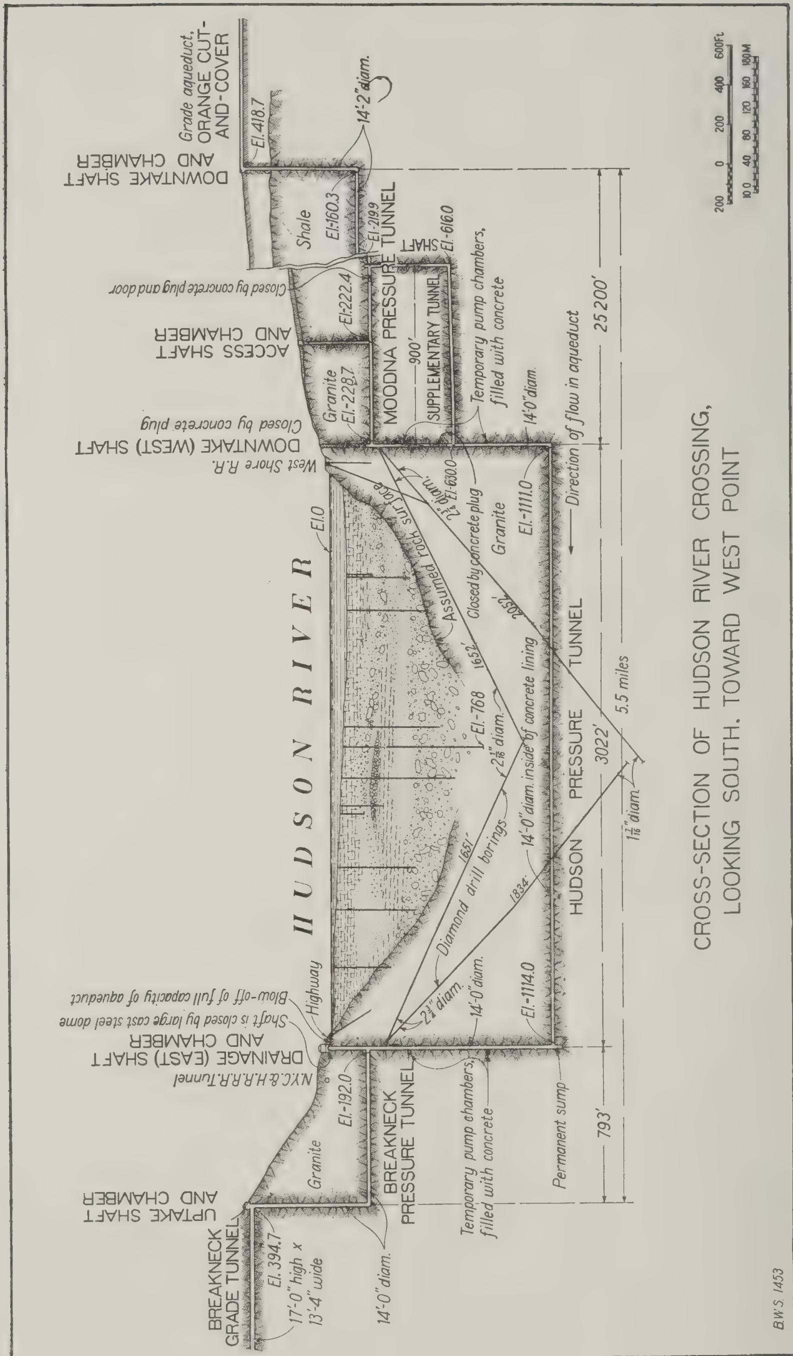
Surveys were completed and contracts were prepared *first* for those portions of the system which would require the longest time for construction. Construction on a large scale was begun early in 1907. Catskill water was first used in New York in 1915 and in regular service in 1917.

THE RESERVOIRS.

Gilboa dam will have its top 1150 feet above tide, or slightly higher than the church spire shown in the illustration. It will have a total length of 2330 feet, of which 1330 feet will be masonry, with a maximum height above stream-bed of 155 feet. Schoharie reservoir will extend six miles upstream and have a capacity of 22,000,000,000 gallons. At the central part of the dam site the creek flows in a rocky gorge, and just downstream passes over a small power dam.

In the valley now filled by Ashokan reservoir were seven villages, with a population of 2000 people, 32 cemetaries containing 2800 bodies, 11 miles of railroad, and 64 miles of highway. This reservoir is 12 miles long and its shore line 40 miles. The maximum depth of water, back of Olive Bridge dam, is 190 feet, and if the water were spread over Manhattan Island it would cover it to a depth of 30 feet, or up to the third-story windows.

At the site of Olive Bridge dam, Esopus Creek flowed through a rocky gorge 40 to 50 feet deep and 200 feet wide. In a dry sea-

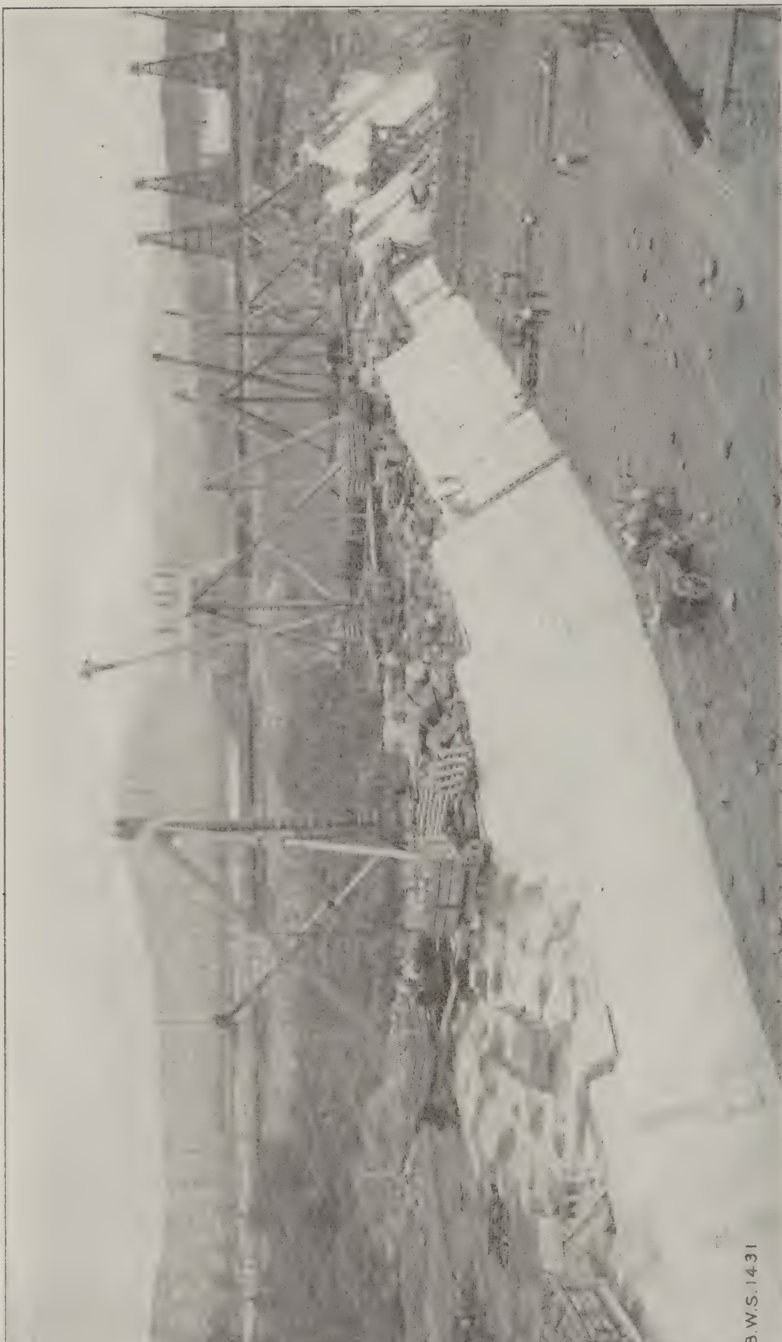


CROSS-SECTION OF HUDSON RIVER CROSSING, LOOKING SOUTH. TOWARD WEST POINT

son two coffer-dams were thrown across the creek and two 8-foot steel pipes laid, spanning the space to be occupied by the foundations of the dam. As the masonry was built up, a conduit 40 feet wide and 40 feet high was formed through the dam to convey the stream until the time should come for filling the reservoir. The dam was built in sections 85 feet long between expansion joints provided to care for slight movements due to changes of temperature, without permitting leakage. It was faced on both sides with large concrete blocks cast in advance. Four great cableways and many derricks handled the materials. Earth for the extensions of the dam was brought in railway cars, spread with scrapers, and compacted with heavy, grooved, steam rollers. On some dikes the earth was delivered by cableways which dumped their loads in the air, and on others the corewall, built up in successive stages, was used to support the railway which hauled the earth. Woodstock dike carries a portion of the relocated Ulster and Delaware Railroad, while most of the other dikes have brick-paved highways on their tops. In the dividing dike is the upper gate-chamber where the aqueduct begins and the admission of water from either or both basins of the reservoir is controlled; at the top of the Beaverkill dikes is the *lower* gate-chamber.

The conduit through Olive Bridge dam was closed in September, 1913, and the water of the creek collected in the reservoir. The completed dam with full reservoir makes an impressive picture with its mountainous background. After preliminary partial fillings and emptyings to wash the reservoir bottom, which had been cleared of all vegetation and structures, water flowed over the waste weir in December, 1916, thus marking the first complete filling of both basins. As practically the whole flow of the stream enters the west basin, the east basin is filled by the water passing over the dividing weir beneath Ashokan Bridge.

To replace the means of traffic submerged, 11 miles of new railroad were constructed on the northerly side of the reservoir, and 35 miles of new highways were built, paved with bituminous concrete, supplemented by five miles of brick highways on the dams and dikes. Stream and railroad crossings necessitated ten bridges in these highways, all of which are of reinforced concrete, the longest, Ashokan Bridge, being 1120 feet, with fifteen arches. Esopus Bridge, at the western extremity of the reservoir, has five arches of 67½ feet span, and Traver Hollow Bridge, with a span



Olive bridge dam, showing methods of construction, four steel cableways suspended between towers spanned the valley and delivered materials, while stiff-leg derricks placed the stones and concrete in the dam. In the background are the concrete mixing plant and the yard where the concrete facing blocks were cast.

of 200 feet, rises 100 feet above the picturesque brook which flows beneath.

Viewed from High Point Mountain, at an elevation of 3000 feet or more, Ashokan reservoir spreads out like a beautiful lake. It is almost as long as Manhattan Island, and its dams and dikes, if put end to end, would extend from the Battery to the Metropolitan Museum of Art. Its capacity is 132,000,000,000 gallons.

In the basin chosen as the site of Kensico reservoir were Lake Kensico and the two Rye Ponds, supplying the Williamsbridge district in the Bronx through the 48-inch Bronx pipe line. The best site for Kensico dam crossed Lake Kensico a few hundred feet upstream from the little dam built in 1885. It was therefore necessary to drain this reservoir, but, as the supply could not be interrupted, two temporary reservoirs were built farther up in the basin and connected to the Bronx conduit by a 36-inch steel pipe, to serve temporarily. The surface of the new reservoir is 110 feet higher than was that of Lake Kensico and is 3½ square miles in area. In emergency it alone could supply the city for several weeks. Its capacity is 38,000,000,000 gallons, maximum depth 155 feet and average depth 52 feet. Only one small hamlet was disturbed in order to build this reservoir.

Having drained Lake Kensico, very deep and extensive excavations for the foundations of the new dam were made by means of steam shovels and standard-gauge railroads, since sound rock was at great depth below the surface in the valley bottom. To place the million cubic yards of masonry in Kensico dam the contractor adopted special equipment and methods. Stiff-leg derricks of unusually great capacity were mounted in sets on travelers supported on wide-gauge tracks carried on concrete piers built into the dam as the masonry rose in lifts of 25 feet. Supplies were brought to the derrick on standard-gauge tracks. So successful was the system that nearly a half million cubic yards of masonry were laid in one season, reaching a monthly maximum of 84,500 cubic yards. By resourcefulness and energy, the contractor completed the dam nearly four years in advance of contract requirement.

Because of its nearness to the city and ease of access by railroad and highway, and because so few of the structures of the waterworks system will be seen by people of the city, it was decided to give this dam a fitting architectural treatment and landscape setting. It is the terminus of the Bronx valley parkway and

Ashokan reservoir, showing portions of the Beaverkill and dividing dikes, the lower and upper gate-chambers. Ashokan bridge, and the dividing weir under the bridge. The east basin is in the background.

already attracts thousands of visitors every week. Its downstream face is of beautiful granite found in a hill about one mile east of the dam, where a quarry was opened by the contractor. The stone is boldly cut and carved in keeping with the massiveness of the great structure, which is 1908 feet long, including the end pavilions, and rises 140 feet above the present surface of the ground. Kensico reservoir necessitated the construction of 15 miles of new highways and the building of four bridges, most notable of which are the three-arch stone bridge connecting the easterly end of Kensico dam with the State highway, and Rye outlet bridge, crossing a narrow portion of the reservoir about two miles north of the dam.

To create Hill View reservoir, 3,000,000 cubic yards of earth had to be excavated by steam shovels and placed in embankments to build up the sides of the excavation. A great wall, slightly submerged when the reservoir is full, divides the reservoir into two basins for convenience of operation, the lower part of the wall containing a by-pass aqueduct so that water can be brought into the city without entering the reservoir, whenever necessary. To facilitate cleaning, the bottom and lower slopes of the reservoir are paved with concrete and the upper portions of the slopes are covered with stone paving. The water rises into the reservoir at its northerly end through a shaft from the Yonkers pressure tunnel and is drawn into the city through a downtake shaft at the southerly end. Over each shaft is a large gate-chamber in which the flow of water is controlled. The capacity of this reservoir is 900,000,000 gallons, and the depth of water 36½ feet.

Silver Lake reservoir is in a natural depression. It also has been divided into two basins, with controlling gate-houses in the dividing dike. Its capacity is 435,000,000 gallons. These gate-houses, like those at the other reservoirs, are of cut cast-concrete stone, adopted because of its excellent qualities and economy. Like other reservoir gate-houses and the buildings along the aqueduct, they are roofed with reinforced concrete tiles, similar in general form to the cut-stone tiles used on the roofs of Greek temples centuries ago. This type of roof was adopted for permanence, to withstand severe climatic conditions, and to resist the occasional mischievous person's stone or rifle shot.

THE AQUEDUCT.

Starting in the *upper* gate-chamber of Ashokan reservoir, the aqueduct, of double capacity, is carried in a deep rock trench

Kensico dam during construction, showing the division of the dam by the expansion-joints. The two cableways spanning the valley aided in handling materials and equipment. The system of derricks on travelers and the single derricks, for placing stones and concrete, are also shown, as well as the railroad tracks for delivering materials to the derricks.

beneath the Dividing and West dikes to the lower gate-chamber, where the flow of the water is regulated by means of numerous valves operated by electric power generated in the building by the flowing water. From this chamber the water is diverted generally to the aerator and thence to the screen chamber, but may be sent directly to the screen chamber, where it is passed through fine screens to remove leaves, fish, and other floating objects. To this building the aqueduct is in duplicate and of special construction. At the south side of the screen chamber the standard aqueduct, of the cut-and-cover type, of 500,000,000 gallons daily capacity, begins.

In constructing cut-and-cover aqueduct, a trench was roughly dug with steam shovels with a bottom width of 21 to 30 feet, according to the character of the earth or rock, the rock, of course, being blasted to prepare it for the shovel. After hand trimming of the trench, the curved bottom, or invert, was placed in alternate 15-foot sections, like a sidewalk, with special joints between. At some places under-drains for ground water had to be provided; at others, soft earth removed or consolidated, or special supports constructed under the aqueduct; at a few small depressions very carefully compacted embankments were built as foundation.

Following the invert, collapsible steel forms of the shape of the inside of the aqueduct were set up in sections of various lengths, and outside them other forms, with space between equal to the thickness of the walls and arch. In a few cases wooden forms were used, and the outside forms were sometimes partly of wood. The inside forms were coated with grease to prevent adhesion of the concrete and secure a smooth surface for contact with the flowing water. The forms having been prepared, concrete was brought from a nearby, or sometimes a distant, mixing plant, in steel buckets on cars drawn on tracks laid alongside the trench. Arrived at destination, the buckets were lifted by a locomotive crane, swung over the forms and dumped, this process being continued until the arch had been completed. Stretches of 30 to 75 feet of aqueduct constituted a day's work. After the hardening of the concrete, the forms were removed, the completed aqueduct covered with earth, and the surface of the embankment planted with grass. In very deep cuts only part of the depth was refilled, three feet of cover over the aqueduct being sufficient. Altogether there are 55 miles of cut-and-cover aqueduct, divided among many contracts, and interrupted by the tunnels and steel-pipe siphons.

Downstream face of Kensico dam and the unfinished park below, looking from the pavilion at the west end of the dam across the terrace at the base of the dam, the pool, with three kinds of jets being tried and the Cascade basins.

Kensico reservoir is the first place where water is normally delivered from Catskill aqueduct. Here a long covered weir of special construction admits the water, and from the gate-house at its end a reinforced concrete by-pass, 11,000 feet long, extends under the margin of the reservoir to the upper effluent gate-house. At the latter water can be drawn either from the reservoir or from the by-pass.

In building the steel-pipe siphons, so-called, sections of pipe 15 feet long, temporarily coated with whitewash to retard rusting, were delivered alongside the trench, in the bottom of which cradles of concrete had been built. The pipes were lifted into the trench, riveted together, filled with water when completed across the valley, and, while under this normal water pressure, covered with concrete. After this concrete jacket had hardened, the water was removed. The mortar lining was placed by pouring it through small pipes set in holes left for the purpose through the concrete jacket, into the space between the inside of the pipe, and forms placed in it. Over the chambers at the ends superstructures have been erected, some of brick with concrete-stone trimmings, others wholly of concrete stone, and a few of local stone, with Concord (New Hampshire) granite trimmings. These steel pipes aggregate six miles in length.

In constructing many of the tunnels the first step was shaft sinking. After starting the digging at the surface, a simple type of head-frame was erected for the hoisting machinery, and both men and materials were lowered into and lifted from the shaft by means of steel buckets hanging at the end of a wire rope. When the shaft had been sunk to tunnel level, a more substantial head-frame was set up and elevators were installed for greater rapidity and safety of operation during the driving and lining of the tunnel.

Methods of excavating grade and pressure tunnels were similar. All tunnels are of such large dimensions that the rock was removed by two operations. Usually the upper part of the tunnel was driven first as a heading and the lower portion removed as a bench, but in a few cases the lower part was taken out first. Drills, operated by compressed air, were used for driving approximately horizontal holes in the heading and vertical holes in the bench. These holes were loaded with dynamite, which was exploded in proper sequence. The broken rock, or "muck," was shoveled into wheelbarrows and dumped into small cars, or

Kensico dam and reservoir and Kensico bridge near completion, viewed from the State highway, which passes along the easterly side of the reservoir.

shoveled directly into the cars, although in a few cases special machines were used. The cars were drawn by mules or electric locomotives to either a portal or the bottom of a shaft and run out on waste piles, or to a rock crusher to be used for concrete material.

Although exploratory borings enabled the engineers to locate the tunnels so as to avoid many difficulties, all could not be eliminated. At some points large quantities of water were encountered which had to be removed by pumping or shut off by stopping with grout the crevices in the rock. In some places the rock was not sufficiently sound to form secure walls and roof and had to be supported. Much of this support was of wood and was removed as the concrete lining progressed; but in the grade tunnels some wooden support was left in place, and in the pressure tunnels permanent steel support was necessary for short stretches.

In lining grade tunnels the side walls and arch were completed first, and then the bottom of the tunnel was cleaned out and the invert placed as the construction tracks were removed. When completed, there is little to indicate on the surface of the ground, even at the portals through hills, that a tunnel has been constructed.

In lining pressure tunnels the invert was constructed first, upon which semicircular steel forms were erected for the remainder of the lower half of the lining. Having completed the lower half, or side walls, similar forms were set for the upper half, or arch. In some cases side wall and arch forms were carried along together and concrete placed in adjacent sections simultaneously. There are 24 grade tunnels, aggregating 14 miles, and seven pressure tunnels north of the city, totaling 17 miles.

Of all the pressure tunnels, the Hudson River crossing has attracted most interest, undoubtedly because its site is so familiar. In order to construct the connecting shaft and tunnel in Breakneck Mountain, on the east side of the Hudson, the contractor laid an inclined railway up the side of the mountain. The entrance to the grade tunnel through Breakneck Mountain is now marked by a small granite building 414 feet above the river. Since the east shaft is utilized not only as a waterway, but also for drainage and access, and since its top is 410 feet below the hydraulic gradient of the aqueduct, it was necessary to close it against this enormous water pressure with a cover which could be conveniently removed, of sufficient size to permit the introduction

Ashokan Aerator and the beginning of the Catskill aqueduct. The large building is the screen chamber, at which the standard aqueduct begins. Following the aqueduct embankment, one comes first to the gaging chamber and, to the left, the two chambers of the Esopus steel-pipe siphon. The lower gate-chamber is just out of the picture at the right.

of the pumping apparatus used for unwatering pressure tunnels. This cover is a cast-steel dome, in one piece, weighing nearly 50 tons, and is held in place on a cast-steel curb ring by 36 tempered nickel-chrome steel bolts, $4\frac{1}{2}$ inches in diameter, 50 feet long, extending down in the concrete lining of the shaft to a cast-steel anchor ring. In order that the joint may be watertight with changes of length of the bolts due to changes of temperature, the bolts are stressed, each time the cover is put on, with hydraulic jacks, so that they always pull the cover against the curb ring. The water pressure on the cover is 180 pounds per square inch, making the incessant lifting force 4,000,000 pounds, and yet this joint, 50 feet in circumference, is as tight as a cork in a bottle. This cover has been placed and removed several times successfully.

For the city tunnel shafts it was required that the temporary structures be as compact and neat as practicable; the one near City College is typical. In Brooklyn and the lower east side of Manhattan the rock was at such depths below the surface of the streets (65 to 146 feet), and also so far below groundwater level, that these shafts could not be started in the ordinary way. Instead, the concrete lining of the shaft, heavily reinforced with steel rods, was built in advance above ground, like a tower, and sunk as a caisson by excavating from within, compressed air being used below water level. The bottom of each caisson went a few feet into the rock and was tightly sealed thereto. Afterward shaft construction proceeded in the usual way.

In the midst of the city extraordinary precautions were demanded in handling the dynamite necessary for tunnel driving. As soon as each shaft had been sunk and the tunnel started, a magazine chamber was excavated at one side of the tunnel and guarded by a door of special construction, so arranged that it would close instantly in case of an explosion within the magazine, thus preventing the force of the explosion and the objectionable fumes from reaching the tunnel or the streets above. During three years of active tunnel driving 10,000 pounds of dynamite were used day after day without serious accident.

For constructing the city tunnels, 25 shafts were required, ranging in depth from 200 to 750 feet, the latter being as deep as Woolworth tower is high. The shallowest shafts are in the central part of Manhattan and the deepest in the lower East Side. These shafts were required not only for constructional purposes,

Kensico influent weir and chamber where the Catskill enters Kensico reservoir. The Kensico by-pass aqueduct begins at the left side of the chamber.

but also as waterways from the tunnel to the distribution pipes. Consequently their lower portions were lined with concrete and the upper portions, from a depth of at least 100 feet in sound rock, were closed with concrete plugs, in which were imbedded one or two steel pipes lined with concrete so as to form waterways 48 inches or 72 inches in diameter.

At the bottom of each pipe is a riser valve, which can be operated from the chamber, for shutting off the flow of water in the event that other means of stopping flow have failed in some exigency, or must be removed for repairs. These valves are also intended to close automatically in the event of a break above causing a great flow of water. The special casting at the top of each riser is known as a shaft cap and is of bronze, as are the two valves bolted to it. At the top of each shaft, under the street or park surface, is a large concrete chamber containing the connections, controlling valves, and meters. Waterways and means of shutting off the water are of the most permanent materials—masonry or bronze, or steel imbedded in masonry—from the tunnel to and including the valves bolted directly to the shaft caps. Possibility of interruption of the flow of water from any shaft is thus minimized. The relations between tunnel, shaft, and street pipes and the buildings above are well illustrated by the panorama at Madison Square.

In crossing the Narrows, a deep trench was first excavated by dredges and then the pipe was laid, beginning at the Brooklyn shore, by means of a powerful derrick boat, specially equipped, carrying suspended from its bow a hinged bridge which extended to the bottom of the trench on a curve that could readily be assumed by the pipe line as the pipes were put together. The inside of the bell, or socket, of each pipe was ground and polished to a mirror-like surface, accurately spherical. Into the space between it and the spigot end of the next pipe molten lead was poured, and after this lead had chilled and shrunk, the slight space resulting was filled by forcing in slugs of cold lead through 32 holes drilled around the bell of the pipe. For forcing in these slugs special steel screws were used, driven by quick-acting devices. In this way a joint was secured which, while retaining its watertightness, would permit the required movement and allow the pipe line to adjust itself to a bearing on the bottom of the trench. Immediately after completion, tests showed that this pipe line, 10,300 feet long, with joints every 12 feet, under a pressure

Pressure tunnel: (1) drilling tunnel "heading" and "bench;" (2) loading dynamite into the holes; (3) removing the "muck;" (4) hauling "muck" out and concrete in; (5) placing concrete lining around steel forms; and (6) grouting crevices in the rock back of the lining.

of 130 pounds per square inch, leaked $5\frac{1}{2}$ gallons per minute; and a few months later, under service pressure of 100 to 110 pounds, a 40-day test gave an average total leakage of $\frac{3}{4}$ gallon per minute—truly remarkable! This pipe was covered with sand and gravel to a depth of 8 feet to protect it from injury by anchors or foundering vessels and other possible causes of damage. A second pipe line will be needed to convey the total supply required by Staten Island and provide against possible interruption.

WELFARE AND POLICE.

Welfare work for the forces of the Board and its contractors received constant attention. So far as practicable, camps were located outside of watersheds used as sources of water supply. Where this could not be accomplished, purification works for the wastes and vigilant patrols were used to prevent pollution. With few exceptions, all garbage and excreta were incinerated and drainage chemically treated or filtered, or otherwise safely disposed of. Each contractor was required to maintain competent physicians, trained nurses, and adequate hospitals, and to examine all employes before admitting them to camp.

To make life more agreeable for the men and help them to self-betterment, especially in the larger camps, evening schools, clubs, amusements, Young Men's Christian Association quarters, and other facilities were provided. In some instances prizes were offered for the best garden. Day schools were maintained for the children. In one camp a post-office and a bank were established. Most camps had general stores or commissaries. Usually camps were on lands provided by the city, and undesirable camp followers and intoxicating liquors were excluded. Little trouble arose in any of the regular camps. Such troubles as did occur were chiefly in the "outside" camps, over which neither the city nor its contractors had control, on land rented by irresponsible parties from local citizens whose desire for profit overcame their sense of morality and public decency.

A commendable record was made for orderliness and healthfulness. No epidemic occurred among the laborers nor in any community in which laborers connected with the work were quartered, nor in communities on whose watersheds camps were situated. As a result of this attention to the human side of construction and of the influence of the camp schools, in which the

men were instructed in the English language and American institutions, a better class of laborers was secured and *there were no strikes.*

Just as the Board of Water Supply was beginning its work, the Legislature passed a law requiring the Board to create a police force for the maintenance of law and order in the camps and for the protection of communities in or near which work was to be done. This force was uniformed and organized on lines somewhat similar to those of the city police, with suitable modifications for rural conditions. It reached a maximum of 387. Most of the men were on foot, but there was a mounted squadron for special duties, and some of the men were equipped with bicycles and a few with motorcycles.

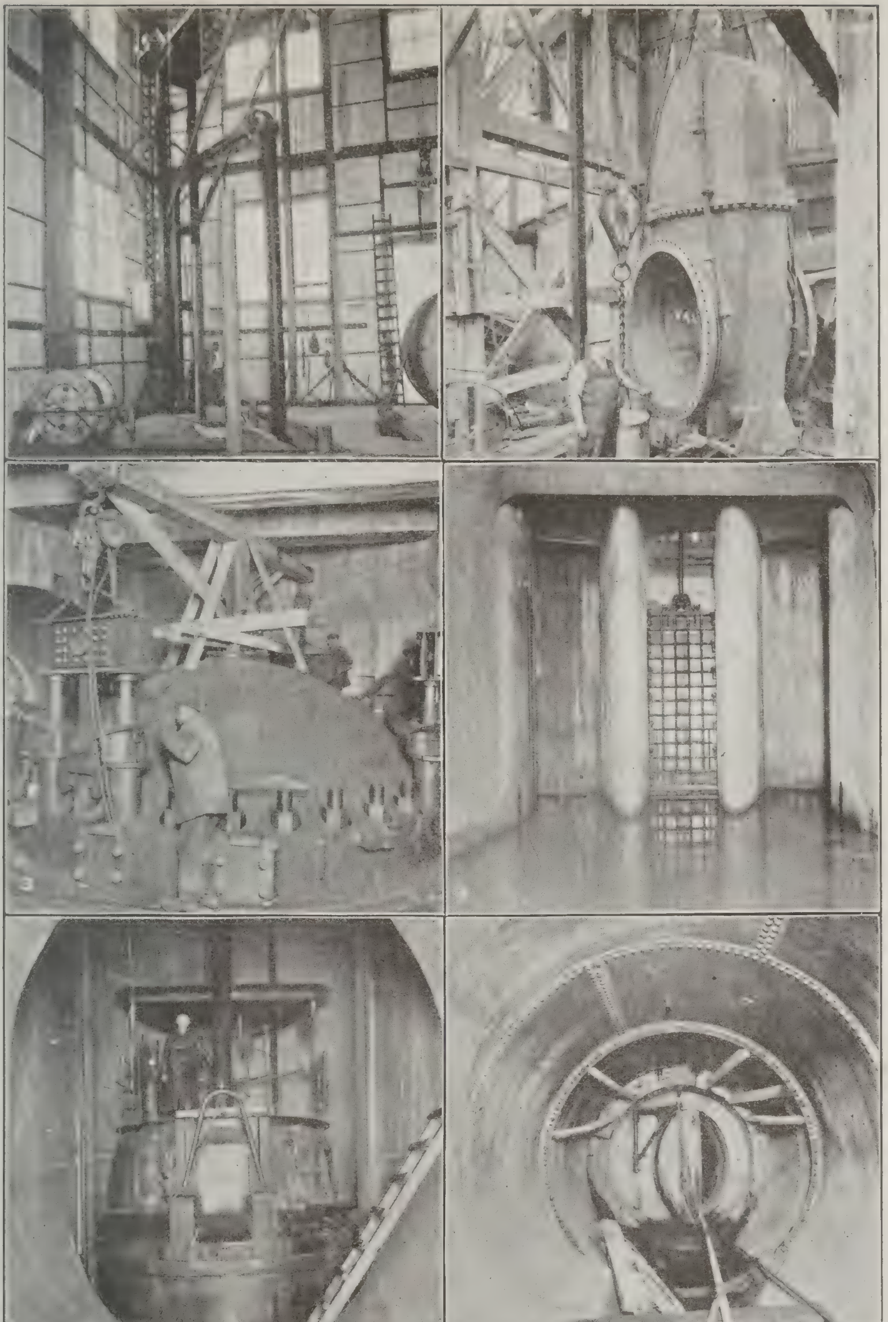
ADVANTAGES AND COST OF SYSTEM.

One great advantage of the Catskill water supply is that its reservoirs in the mountains are at such elevations that the water can flow to the city by gravity and be delivered at such pressures that it will rise without pumping to the levels necessary for service in practically all parts of the city, in buildings of reasonable height.

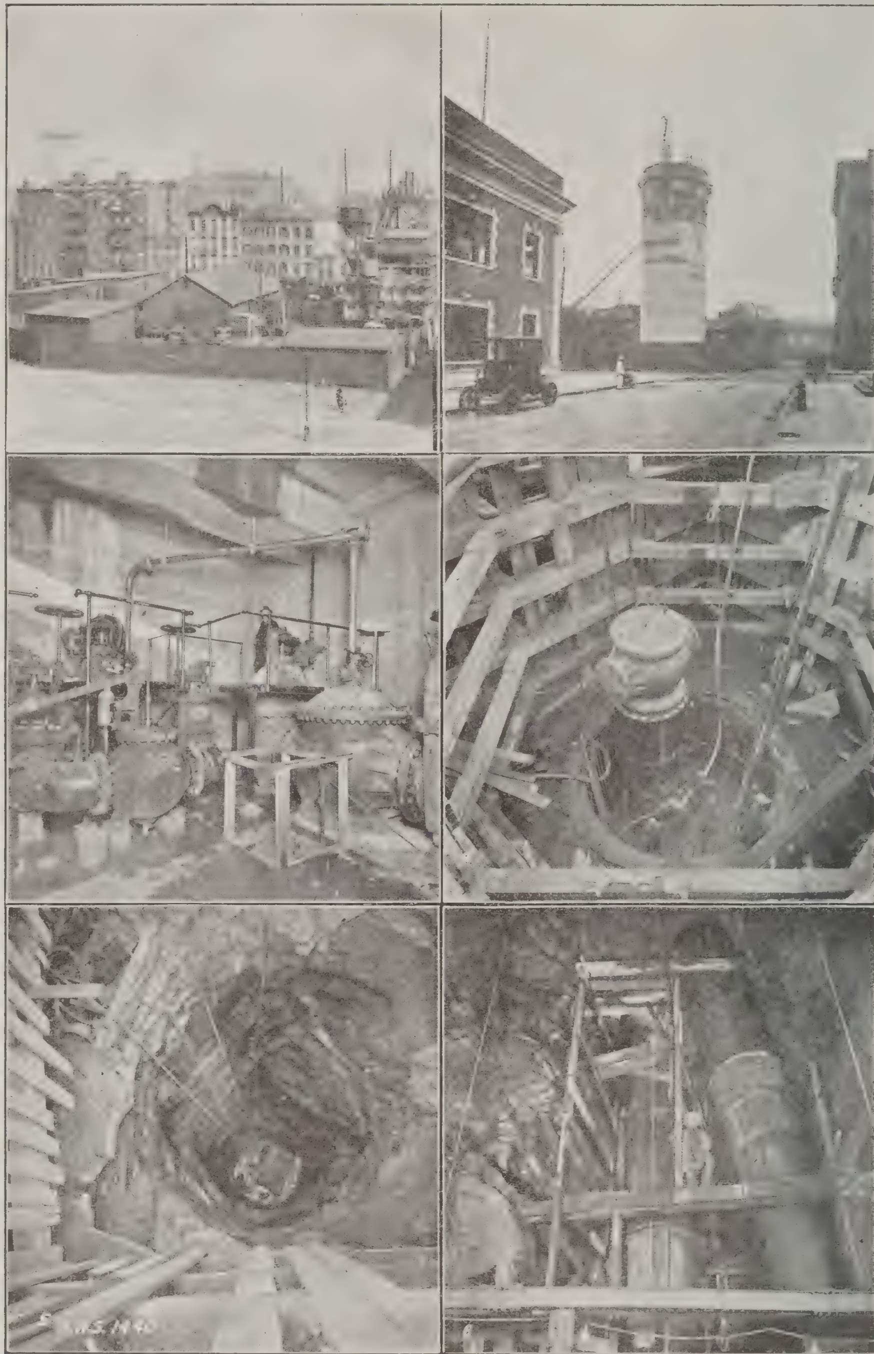
It has been estimated that pumping, costing the city and private individuals approximately two million dollars per annum, can be eliminated. A gravity water system, requiring but few men for its operation and most of them unskilled, is but little affected by rises of wages or by labor troubles. This great gravity supply, from which 375,000,000 gallons daily have been drawn for months, has been of inestimable value to the metropolis in this severe winter with the scarcity of fuel caused by the country's unpreparedness for wartime conditions.

Catskill aqueduct reaches all boroughs of the city and interconnects the other permanent supply and distribution systems as has never been done before.

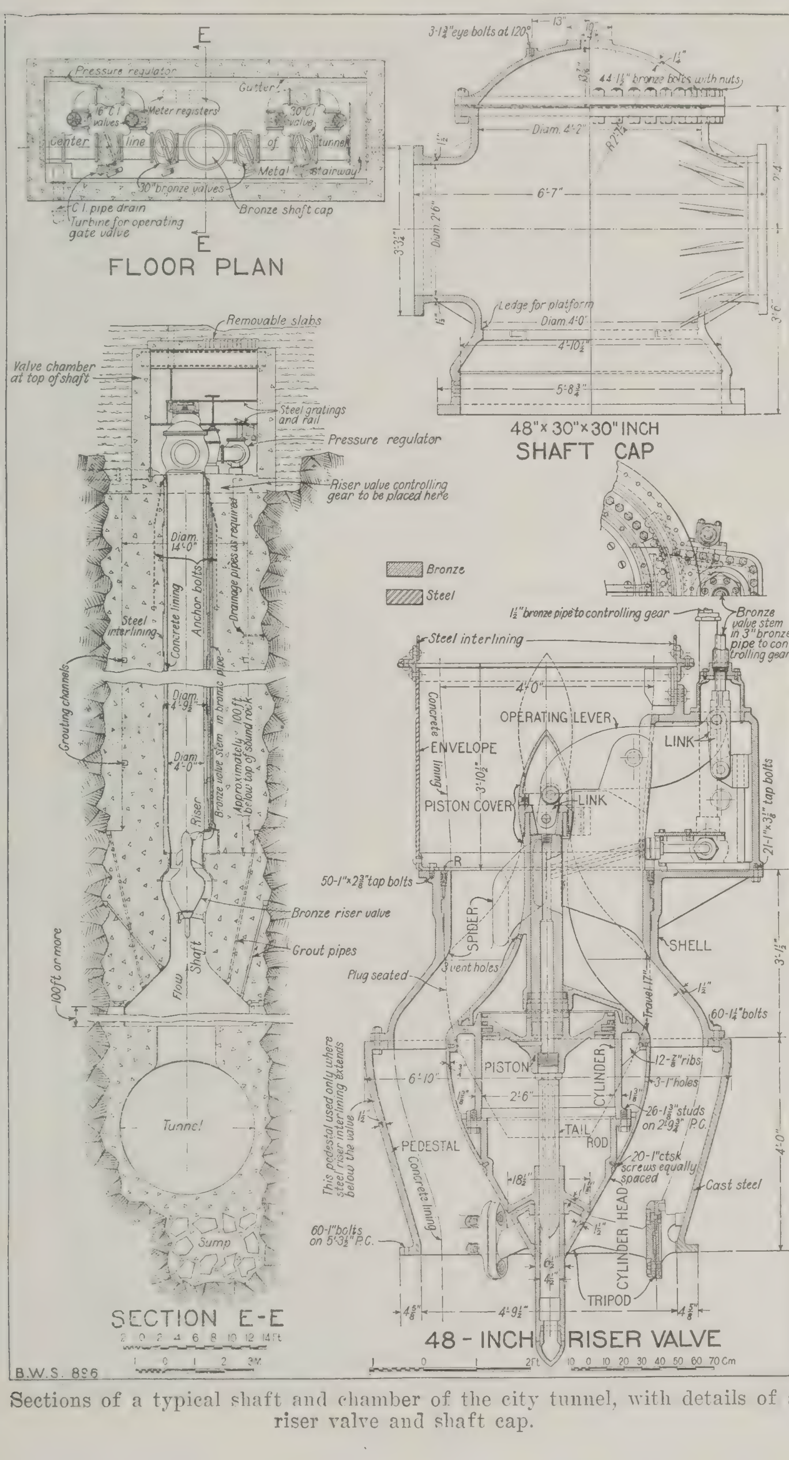
The first portion of this system has been completed within the anticipated time and at less than the expected cost. The estimated cost of the entire work was $177,000,000, to which subsequent legislative action added $8,000,000, making the total revised estimate $185,000,000. Disbursements and liabilities to October, 1917, amounted to $139,000,000, and the estimated cost of completing the whole system, including $22,000,000 for the Schoharie project, is $37,000,000, a total of $176,000,000—$1,000,000 less than



The building over a drainage shaft showing the discharge pipe and power, lighting and telephone cable reels (1); (2) a huge bronze valve ready to be lowered into a city tunnel shaft; (3) the steel dome and anchor bolts on top of the Hudson Drainage shaft; (4) the connection chamber and a sluice-gate at the junction between a steel-pipe siphon and cut-and-cover aqueduct; (5) the unwatering equipment in the Hudson pressure tunnel, at the bottom of the drainage shaft; (6) the bronze door in a drift connecting an offset drainage shaft with a pressure tunnel.



Contractor's plant at the top of a city tunnel shaft (1); (2) a reinforced concrete caisson being sunk through sand to rock for a shaft in Brooklyn; (3) interior of a valve chamber on top of a finished shaft; (4) a shaft top nearing completion, showing a riser pipe and shaft cap; (5) looking down into a shaft during the process of sinking; and (6) steel riser pipes in a shaft ready to be imbedded in concrete.



Sections of a typical shaft and chamber of the city tunnel, with details of a riser valve and shaft cap.

Laying the Narrows siphon from Brooklyn to Staten Island. At the left is the clam-shell dredge boat with its scows and at the right the pipe-laying barge and the submerged bridge used to support the pipe-line as it was put together. The barge and bridge were moved forward as the pipes were added to the line so that the pipe line was paid out like a chain into the bottom of the trench. Subsequently the pipe was covered over with sand and gravel.

the engineer's original estimate, and $9,000,000 less than the estimate corrected for expenses added by legislation.[1]

IN CONCLUSION.

This description of the physical works which make up New York's Catskill Mountain water system must be supplemented by mention at least of the ability and resourcefulness of the contractors, many of them engineers, who wrought with the Board of Water Supply and its staff, of the ingenuity of manufacturers who furnished materials and equipment, of the generosity of engineers in many parts of the country who contributed information and suggestions from their experiences, and of the coöperation of city and state officials. The commissioners of the Board of Water Supply are Charles Strauss, president; Charles N. Chadwick and John F. Galvin. J. Waldo Smith has been chief engineer from the beginning.

When, hereafter, a citizen of New York gazes upon beautiful Kensico dam he must remember he is enjoying the fruits of the labors of many men, expressed by this imposing structure as the token of the underground artificial river and its lakes by means of which water from the distant mountains is constantly available for every use in the homes and marts and factories of the metropolis. And so substantially have these works been built that they should still be useful after the lapse of centuries. But New York's water problem has not been permanently solved; with continued rapid growth it will soon be necessary to take preliminary steps toward the next increment, for ten or even twenty years hence are but as to-morrow in dealing with this city's gigantic public works.

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[1]Important items of such legislation were the decrease of the legal length of the working day from ten hours to eight, the requirements for a special police force, and the workmen's compensation act dealing with injuries and insurance.

TUNNELS AND GALLERIES.[1]

Our advance in November on the left bank of the Meuse and especially in the region of the Mort-Homme put us in possession of numerous works constructed by the Germans in this region. Here we have another evidence of their care in the organization of positions and their obstinacy in planting themselves on the conquered ground. One of the works which doubtless strikes our soldiers most is the excavation of the tunnels of Gallwitz and of the Crown Prince, each of which attains the length of 1 kilometer, and provides for a debouch on the southern part of the Mort-Homme without having to cross the ridges constantly swept by our artillery. Judging from their appearance, these works were surely constructed by the Wesphelian miners, for they present all the characteristics of the mining galleries in use in that country.

These tunnels are generally 2.20 m. to 2.30 m. in width at the base, 2 m. at the top, and 2 m. high. They are made of the trunks of trees not squared, inclined and assembled as usual on the sills and top pieces of the same nature. Solid roof planks prevent the earth from falling in between the frames; others are slipped over the inclined walls when this is thought necessary.

Of course such a gallery can afford a passage not only for the numerous troops assembled there, but also for the wagonettes running on a .60 m. track and bringing to the foot of the work, material. provisions, and munitions. It serves also as a shelter for an entire company, for there are numerous cells dug perpendicularly to the gallery furnished with camp or other beds.

Toward the center of the tunnel, vast chambers shelter a complete power plant which not only lights the tunnel itself and the adjacent chambers, but also serves to dig new niches by the use of punching machines.

We naturally find there all the accessories of a barrack with spacious kitchens, shower baths, water closets, and also luxurious

[1]Translated by Col. W. R. Livermore from *La France Militaire,* February 14-15, 1918.

quarters for the officers, furnished as a rule with the plunder of the unfortunate inhabitants of our invaded country.

Those of our troops who have never seen such works are naturally enraptured to find subterranean shelters so vast and comfortable, and have been tempted to declare that our enemies appear to be our superior in the latter respect. Nevertheless, it is well not to countenance such fables, which are easily refuted by comrades who have themselves lived in shelters, not indeed as well furnished—because we respect other people's property—but relatively as comfortable as most of our command-posts and gallery-tunnels.

These are not the works of today alone; if we remember rightly, tunnels more than 600 meters long have been dug for a long time, especially in the Argonne. They are also, we think, the work of our infantry, and they contain very good electric plants distributing light and power to the very front of the firing line.

Such works exist in the East and in the Champagne. They yield precedence in no respect to the work of the Germans. They have rendered very great services, and our engineer sappers who have dug them have no cause to envy the Wesphelian miners of the Mort-Homme.

At first, the Command hesitated for a long time to dig such long galleries, naturally requiring a numerous personnel, many hours work, and a relatively considerable expenditure of wood. Besides, we have always been haunted by the idea of an advance, and said to ourselves, "What is the use of dispensing with so much power and material for a very uncertain object." Nevertheless, the perspicacity and the tenacity of some of our officers have succeeded in conquering the apathy of many others.

We, however, began timidly with galleries just wide enough for wagonettes of .40 m. to pass. In view of the success of these first works and also because of the prolonged stagnation of the troops on the same emplacements, it has been decided to conduct them more vigorously. At first, we widened the galleries for a .60 m. road, as our enemies did on the left bank of the Meuse. Moreover, instead of regarding them as passages only, we gradually transformed them into chambers for the men, and quite naturally provided them with electric lighting. The power thus generated served also to dig new galleries. Almost all this work has been done in ground comparatively hard and sometimes even in rock, which explains how we have had to resort to percussion

hammers and pneumatic drills; that is to say, we have been led to install veritable factories close up to the enemy's lines, and without the slightest inconvenience.

We have multiplied the subterranean shelters for the troops, and the command posts for the officers and the general staffs.

We think that at present we have no reason to envy the Germans, and we certainly possess as many shelters, galleries and tunnels as they do. We have not, perhaps, brought up as much furniture; but that is simply because we have different ideas about appropriating other people's property, and we have not the same instinct for pillage. This is all to the honor of the officers and men of our troops.

SOME NOTES ON THE TURKISH TRENCHES AT SANNAYAIT.[1]

By

Bt. Maj. W. H. Lang

16th Cavalry, British Army, India

After taking the Sannayait our advance was so rapid that only a hasty walk round the Turkish trenches was possible. It was the writer's fortune, however, to see the first two Turkish lines after their capture before they had been completely consolidated by us, but even then they had been so badly knocked about by our shell and mortar fire, and the process of converting the second line from a Turkish trench into a British one had progressed so considerably, that the original dimension of either line was not easy to estimate. A short description of the surrounding country may interest.

Roughly speaking, the Turkish position ran North and South. The Tigris flowed at right angles on its Southern Flank while the Suwaika marsh protected it from the North. At the time of our attack in February the waters of this marsh were lapping against its northernmost trenches.

The country is absolutely flat, broken only by the parapets of our respective trenches.

Our fifth trench was provided with an exceptionally high parados into which were arranged observation posts. These posts gave us a command of some 8 feet, but owing to their visibility were unhealthy spots. The height of this parados defiladed the ground behind it and allowed us to move about in moderate safety except from "overs" and an occasional shrapnel.

The river bank was fringed for some 100 yards with thick undergrowth. This was particularly the case in "no man's land" where it reached a height of some four feet.

Our respective front lines were from 80 to 150 yards apart.

"No man's land" itself conformed to the rest of that part of Mesopotamia. It was quite level but pitted badly with shell holes,

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[1]Reprinted from *Journal of the United Service Institution of India*, October, 1917.

while the river edge was covered for some 100 yards with thick undergrowth. This undergrowth was barely an obstacle.

It was the cockpit of many a bloody affair of bombers, and snipers always could be found lurking in it both night and day.

Owing to its thorns it was a most unpleasant strip to crawl about in.

For the rest, shell holes formed the only cover between our front lines. Not the vast shell holes of Flanders, only craters some four feet deep.

From the river to L10 the Turks had no wire entanglement standing; of that our artillery observing officers took good care.

The Turkish Front Line. The Turkish front line showed once again the strength of an irregular trace. Aeroplane photos led us to expect an irregular trench but not such a one as this.

In general outline it was a wavy line with salients covering re-entrants but beyond that there was nothing regular. No two fire-bays were the same length or even depth, no two dugouts the same size or situated in the same part of a bay, no two traverses were of the same thickness and even the breadth of the trench varied very considerably.

The front line itself was a single trench with no inspection trench behind it. In some places over 10 feet deep, in others little more than 6 feet. In breadth it averaged five feet but was much narrower at the traverses.

Revetments of all kinds had been improvised. Sandbags, flour sacks, brushwood, marsh reeds, rabbit-wire all played their part.

The parapet gave a low command of about one foot, but the parados was ample and irregular.

The firing step was normal, above the firing step were holes for storing bombs and ammunition, while below the firing step were the dugouts.

The dugouts consisted mostly of long holes of varying lengths about 4 feet high entered by slits some 2 feet broad between the firing step and the bottom of the trench.

The roofs of these dugouts were shored up by planks and timber.

It must have been difficult for a man to get into and out of these dugouts even when not wearing his equipments, but they were proof against our heaviest artillery. A rough sketch shows the arrangement of a bay, but few of these were exactly similar.

In many places protection was afforded for some of the garrison by scoops in the side of the traverse.

The traverses were all very deep and broad, for it must be remembered that the Turks had to contend against enfilade fire from the other bank of the river which was in our hands.

A listening gallery had been dug some 25 yards east of and parallel to the front line. It ran practically continuously from the river to F2. This gallery consisted of a tunnel some 3 feet 6 inches square, of which the roof was 2 feet below ground level. Planks and corrugated iron shored up with timber of all descriptions kept its roof from falling in.

The gallery crossed the many saps shown on the map and relied on them and on holes in its roof for air. In it there were no signs of mines or electric wires nor was any trace found of a wire for obtaining induction from our telephones.

It seemed to be purely a defensive gallery against our mining, although it is quite possible that snipers and lookouts used the holes in its roof.

The soil had been used either to fill up superfluous trenches and holes, of which there were many behind the front line, or had been thrown on the parados thereof.

There were many saps forward from the front line, mostly under 50 yards long. Some were used by bombers and snipers but in none were machine gun emplacements seen.

The whisker-like marks shown on the map attached in rear of the front trench represent places for domestic arrangements and a few dugouts, probably for platoon commanders, etc.

From the front line along the edge of the river and parallel to it a high bank had been constructed by the Turks to keep the river from overflowing during the flood season. This bank was also of great assistance to the enemy in protecting him from our machine gun fire from the southern bank of the river, particularly during his counter-attacks.

No flammenwerfer gas cylinders were seen in the trenches, although a length of hosepipe was found in the front line near the river, which was used for drawing water. This piping was probably responsible for the various statements of flammenwerfer pipes and gas nozzles which had from time to time been current.

Second Line. The second line where it existed was used as an inspection or communication trench. It did not appear to have

been lived in. It was not provided with dugouts, nor was there any wire entanglement in front of it.

Four circular trenches near F were interesting. They first figured in our aeroplane photographs about August, 1916, when the Turkish big minniewerfer started operations. These circles were found to be merely shallow fire trenches unless they were designed as dummy minniewerfer emplacements to draw fire. No reason can be given for them; if that was their motive they were most successful.

Third Line. As our troops had not consolidated this line it was found more in its original state than the first two trenches. From the river to F18 there was a low wire entanglement some 15 yards in front of the parapet. This wire was 10 yards broad on poles, roughly 1 foot high, and would have made a nasty obstacle if it had not been destroyed by our gunfire.

It was countersunk and protected by a parapet 1 foot high. Beside protecting the wire, this parapet gave the impression that it was the enemy's "third line" and caused a good deal of our shooting to fall short.

From F18 northwards the trench for wire entanglement had been prepared, but no wire had been placed in it.

The class of barbed wire used by the Turks in this entanglement varied considerably, but it was mostly a very light poorly barbed wire, not nearly as formidable an obstacle as our barbed wire affords.

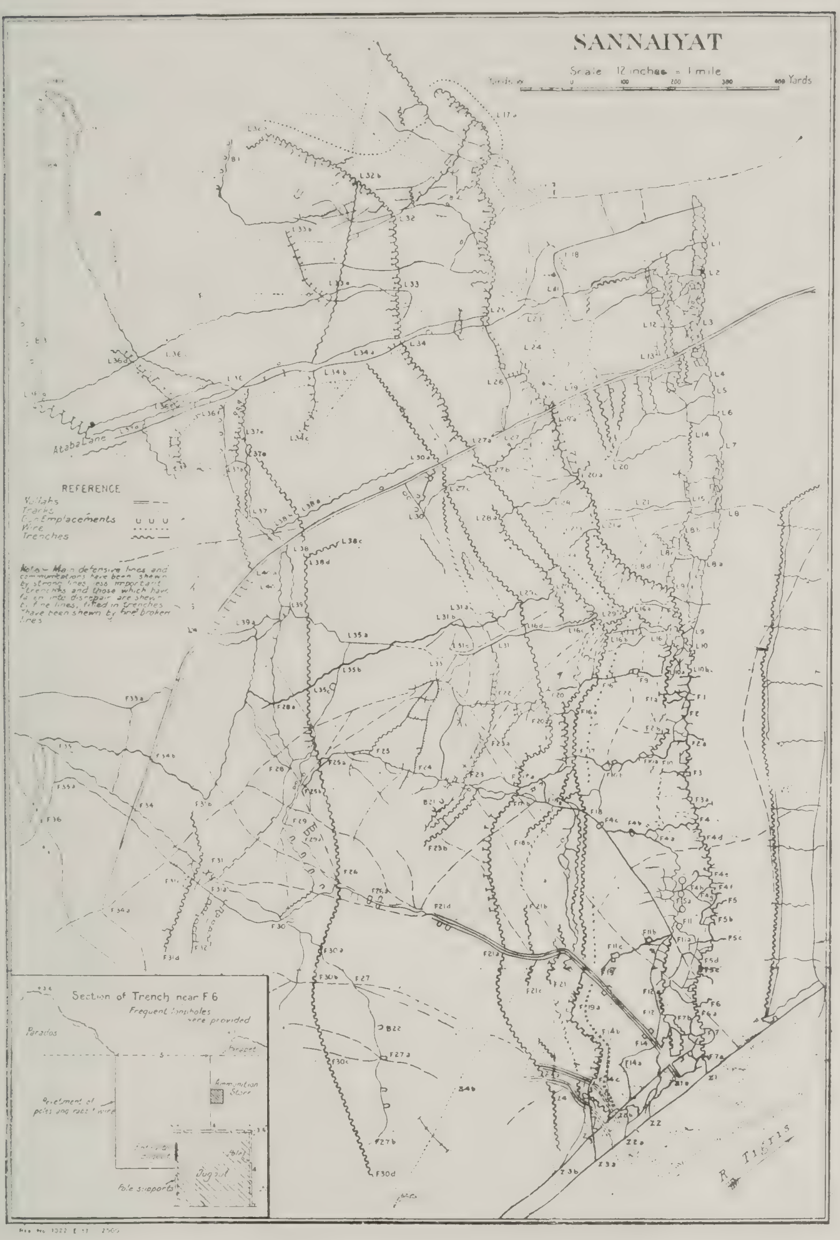
The third line itself consisted of a fire trench and in some places a support and also an inspection trench. Where the fire trench was single (*vide* sketch) it was some 6 feet deep, provided with a fire-step, irregular traverses and a few dugouts with overhead cover. From F19 to F18 there was a triple line of trenches with dugouts in the central one.

The sides of the trenches were, generally speaking, not revetted, and none of the dugouts were more than splinter proof.

With the exception of those in the front line there appeared to be no dugouts in the trenches which had been provided with overhead cover sufficiently strong to resist anything heavier than an 18-pound shell.

In the front line only was revetting material used. The remaining lines had been starved even of sandbags.

Machine Gun Emplacements. No machine gun emplacements provided with overhead cover were recognizable in the first two


SANNAIYAT
Scale 12 inches = 1 mile
Yards
REFERENCE
Tracks
Emplacements
Wire
Trenches
Section of Trench near F 6
Frequent loopholes were provided
Parados
Ammunition Store
Dugout
Pole supports
Ataba Lane
R. TIGRIS

lines and the only emplacements seen were sited for oblique fire, without overhead protection.

In these great care was taken not to disarrange the trace of a trench and so give away the position of the emplacement to aeroplane photographs.

There appeared to be no special protection for either the machine gun or the crew during a bombardment.

No emplacement was found in the parados or between the first two lines and it was noticed that traffic control posts like F14F 11*b* emplacements were not provided, even though such positions would fire down a straight length of trench.

The writer was disappointed to find no trace of interdependent emplacements from which no man's land could be locked. It seemed that the Turks trusted more to changing the position of their guns frequently than to building shell-proof emplacements for them.

Big Minnie. One big minniewerfer (throwing 150 bombs) was inspected. The pit was roughly 10 feet deep by 10 feet by 9 feet. It was partially covered with light overhead cover as protection from aerial observation. It relied on the depth of the pit to hide the flame on discharge. The walls were partially revetted and the dugouts in the vicinity were safer than usual.

Communications. The main system of communication trenches shown on the sketch were deep narrow trenches, in some places 12 feet deep. Their irregularity must have largely contributed to their safety. There were very few trenches along which stretchers could have been taken. There was no deliberate straightening of the last length of a trench so as to check a bombing attack.

The only telephone wire ran down the Ataba lane and stopped at the fourth line. It consisted of a bare wire suspended on the top of wooden posts, which were fixed to the side of the trench and projected some 2 feet above ground level. Crossing places were arranged. Every station on the circuit was apparently tapped in to this wire.

Water. The river was too high in February to make it possible to see how the Turks used to draw their water during the summer, but it appeared that they dug deep reservoirs just north of their river bank and filled them by hand pumps, the piping of which was carefully concealed.

ORGANIZATION AND DUTIES FOR TRENCH FIGHTING[1]

By

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CHAPTER VI. ATTACK OF A POSITION.

Phases of the Attack. As we have already learned, the attack of a position by a unit comprises three phases:

The preparation of the attack.
The assault against the first hostile line.
The exploitation of the success by fighting in the interior of the position for its occupation.

These phases are the same as those in open-ground warfare, but their importance, aspect, and order are not the same. Especially the preparation of a trench attack is such a preponderant phase of the attack that upon the manner of its execution depends the success of the attack. The exploitation of the success is a long and decisive operation. In trench warfare, the assault is only the beginning of the fighting for a position, and its purpose is to make a breach in the enemy's first line. Through this breach, the reinforcing and reserve troops are pushed in behind the assaulting columns to deliver the real combat for the capture and occupation of the position.

Thus we see that the assault, which in open-ground warfare is the final phase of the battle, is, on the contrary, in trench warfare the first move of the fight. In open warfare, the order of the battle is: the preparation, the approach march and infantry combat, and finally, the assault. An offensive in trench fighting

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[1One of a series of lectures on ''Tactics and Duties for Trench Fighting,'' given by Captains Solbert and Bertrand. Now published in book form by G. P. Putnam's Sons. Copyright, 1918.]

consists of, first, the preparation; next, the assault against the first line; and last of all, the interior fighting for the position.

The cause of this reversion of the rôles of the attacking troops in a trench offensive operation lies in the strength and stability of the fortified front. It is impossible to maneuver against a continuous line which extends without a single breach. It is only possible to maneuver behind the first line or within the position after a breach has been made. If a part of the first line gives way before the pressure of the assailants, the leader of the attacking units pushes forward his troops through this breach without consideration of the strategical value of the part of the line broken.

I. PREPARATION OF THE ATTACK.

Front of Attack. The tactical unit for an attack is a division. A division that is placed in the front line for this purpose is called an attacking division. To such a division is assigned the task of attacking and capturing a definite length of front of the hostile position. All the necessary means to carry out this mission are in the hands of the division commander.

The tactical unit for an *assault*, in this division, is the battalion. Each assaulting battalion is placed in front of that part of the hostile line against which it is to operate, which is called its front of attack. The length of this front is variable with the tactical situation. Also, this length in no way indicates to the enemy the strength of the attacking troops because they are disposed for the attack in depth. According to the size of the front of attack, the battalion commander will place two or three companies in the assaulting column, and two or one company as reinforcing support.

Conditions of the Assault. An assaulting battalion must be disposed in a certain manner, which is called the assaulting disposition. In establishing this disposition, we must consider the distance of the assault and the outline of the assaulting lines.

Distance of the Assault. The distance over which the troops make their assault across "No Man's Land" must not be too great. This is to avoid as much as possible the enemy's barrage and machine gun fire. For this reason, parallels of departure or jumping-off trenches, if necessary, may be constructed out in front of the first line for the assembling of the assaulting troops. On the other hand, your own first line should not be so near to the

enemy's position as to be in the zone of artillery dispersion when your own batteries are firing at the enemy's first line. However, one is not always master of this distance, as it is a result of long fighting and occupation of the two positions. The proper concealment of these attack works, such as the parallels of departure, is an essential condition of success.

The Trace of the Lines of Departure. The trace of the lines of departure must be parallel to the first line of the enemy, not to your own, so that the assaulting troops will simply have to start in a perpendicular direction from the lines of departure to reach their objective. In other words, the assault is a simple frontal attack without maneuvers.

Ground Preparation for the Assault. It follows from the statements of the conditions of the assault and also of the tactical and material preparation of the attack, that the terrain from which these troops will start must be specially organized for this purpose. We have discussed the principles and details of the organization of the position for the defense, and it is clear that these must differ materially from those for the attack. An attack, like a defense, is made with the units disposed in depth. To launch an attack, certain of the defensive works that play but a passive rôle in the resistance, such as barbed wire entanglements, must be rearranged, modified, or partially eliminated. Other elements, such as routes, boyaux, and supply depots that facilitate the forward movement of reinforcements, are multiplied.

Details of the Preparation of the Ground for the Attack. All the details of the preparation of the ground for the attack are laid down in an order called the ''Plan of Ground Disposition,'' issued by the general of the attacking division. This order is divided into two parts: the organization of the works, and their execution.

Organization. We know that the disposition of an assaulting unit is in the form of successive echelons, called waves. In order to protect these waves before the assault, it is necessary to construct for them trenches parallel to the enemy's first line; and for this reason these are called parallels of departure. The trace of the first parallel fixes the directions of the others behind. For example, an assaulting battalion which is going to advance in four waves, might have two parallels of departure with two waves in each parallel. These parallels are narrow trenches like the

defensive lines, but with a series of steps in the front side so that the men can go over the top easily. If there are no steps, trench ladders or footholds must be used.

Theoretically, one might think that the distance between these successive parallels should be the same as that between the attacking lines. But this is not practicable. Such practice would mark out boldly on the ground, for the enemy's air observation, your intentions and your dispositions for the attack. Therefore, this method is strictly prohibited. Besides, it is not necessary, since the regulation distances between the lines and waves are not realized from the point of departure of the assault. The object of the assaulting companies is to cross "No Man's Land" as quickly as possible to avoid the enemy's defensive barrage and machine gun fire. Consequently, when the different lines of the first wave jump out of the same parallel of departure, they will dash across to the enemy's first line with little regard to distances but with a fixed idea of reaching their first objective before the hostile garrison, and before the enemy's barrage intervenes. They attain their regulation distance as soon as the zone of barrage is passed and when they have arrived at and crossed the first hostile line.

In order not to print the attack on the ground, so to speak, these different parallels of departure are not constructed in front of your position unless absolutely necessary. They are constructed when the distance across "No Man's Land" is more than five hundred yards, when there is natural cover, such as woods to conceal them, and sometimes on reverse slopes. The different defensive lines of the sector make very convenient parallels of departure. The first waves of the assaulting company are placed in the firing and cover trenches of the first line. The reinforcing platoons are disposed in the transversal and intermediate and support lines. Behind these lines are constructed *places d'armes* or assembling places for the reserve troops. These *places d'armes* consist of a series of short transversal trenches leading off both sides of a central boyau.

If the first hostile line is too far from our own first line, on the night previous to the attack, hasty parallels of departure are constructed out in "No Man's Land" for the leading wave of the assault. This is to give this leading element the best possible chance to arrive at the enemy's first line uninterrupted by artillery fire and before the hostile garrison.

The work of preparing the ground for the disposition of the attacking troops also comprehends the following:

Several boyaux.

Command posts and observatories in advance of those of the defensive sector. Each chief must now be in the middle of his unit and not behind it.

Depots and medical-aid stations. Each company has its own little ammunition depot near the post of the captain.

Ditches for telephone wires. Each battalion has telephone wires brought up in its main boyau as far as the first parallel. At this point, telephone material is stored so that the system can be carried into the enemy's position with the least delay.

Small bridges are constructed for the passage of the parallels by the reserves.

It is not necessary that the shelter accommodations be numerous, especially in the first line, because the assaulting troops are brought in only a few days before the attack.

The Execution of the Works. The second part of the plan of ground disposition contains the details of the execution of the works for the preparation of the ground previous to the attack. This part consists of:

1. Emergency works (necessary to the assault).
   - Observatories and command posts.
   - The first two parallels of departure for each battalion. If none need be constructed, the defensive lines used for this purpose are designated.
   - Secondary boyaux between parallels, one for each company.
   - Entrance and evacuation boyaux.
   - Ammunition depots and water points.
   - Dressing stations.
   - If there is more time, the following are constructed:
     - The third and fourth parallels.
     - Telephone wires and material brought up.
     - Bridges for crossing the parallels.
2. Time of duration of the execution of the works.
   This may vary from three to twelve days, or even more, depending upon circumstances.
3. Division of labor.
   This depends upon the number of special working parties at your disposal. A whole division may be assigned for this work, but it is not the division that will make the attack.
4. Tools.

The tools required for this work are requisitioned from headquarters of the attacking army.

5. Ammunition depots.
   Cartridges, hand grenades, and signal rockets.
6. Ammunition depots.
   Sandbags and logs.
7. Transportation of supplies.

Special means of transportation besides the usual ones, railroads, motor trucks, mules, horses, etc.

ARTILLERY PREPARATION.

During the time employed in preparing the ground for the attack, the artillery executes the preliminary bombardment. This comprehends three kinds of fire.

1. *Counter-Battery Fire.* A certain part of the artillery is detailed to destroy the hostile batteries or, if this is not possible, to neutralize them. This result is obtained by methodical fire on precise targets. Each battery or group of batteries is assigned certain emplacements to destroy. Counter-battery fire is long-winded work and is begun several days or even weeks before the attack. If the hostile batteries are not destroyed before the time of attack, they must be neutralized at this moment by violent shelling by all the batteries disposed for this purpose, with shrapnel and other special shells. This counter-battery action will hinder the hostile artillery from executing defensive fire, barrage, preventive fire, counter-preparation fire. It is carried out by special groups of heavy and light artillery under control of the general.

2. *Fire on Communication Routes, Depots, etc.* This fire, besides its destructive effect upon the enemy's position, hinders the arrival of reinforcing troops, material, ammunition, and food. The shelling of distant roads, depots, and bivouacs is carried out by batteries of long-range guns. The fire on the nearest communications, such as interior supply routes, entrances of boyaux, kitchen emplacements, etc., is executed by light batteries of the divisional artillery.

3. *Destructive Fire.* Before the attack the whole of the enemy's position is submitted to methodical and violent artillery fire for the purpose of destroying:

Obstacles which may hinder the advance of the assaulting column: accessory defenses, such as barbed wire entanglements.

Elements of the defense, such as strong points, machine gun emplacements, observatories, depots, shelters, and dugouts.

Each different kind of target calls for a certain number of rounds of a particular caliber. These calculations of the different numbers of rounds are the results of experience and are set down in tables for the information of the sector commander. The time, therefore, necessary for a proper preparation for the attack is a function of the number and strength of targets. The artillery preparation may last from one to twenty days, but it must continue until the elements of the hostile position are sufficiently destroyed to assure a successful attack.

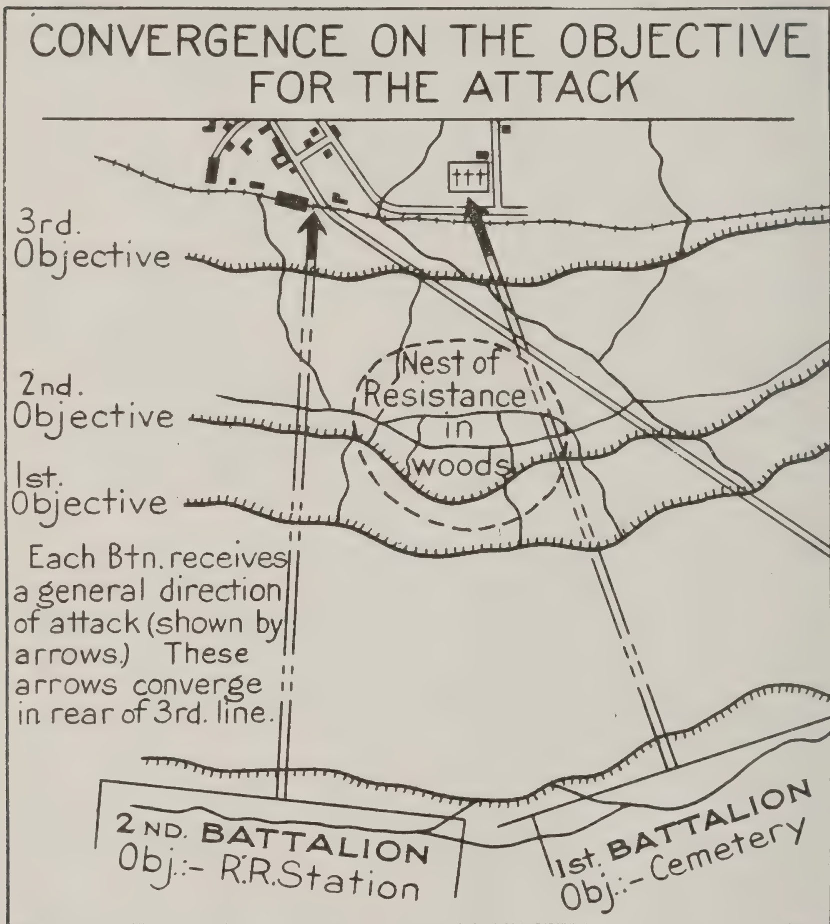
Before an offensive, there is placed at the disposal of the attacking divisions, besides their regular divisional artillery, a special allotment of batteries. The different calibers of guns are used according to the nature of the target. The largest calibers are employed against the strongest elements of the organization: nests of resistance, strong points, and deep dugouts. Light artillery is used to obliterate trenches and boyaux and interior barbed wire entanglements. Trench mortars serve to destroy the elements of the first line and its accessory defenses.

Plan of Artillery Action. The details for the execution of these different artillery fires are laid down in the plan of action of the artillery of the army corps or of the division. This plan is a part of the plan of battle of the division. These details must be carried out punctually and with precision. The sector commanders are not interested directly in the execution of these fires, but they are in their results.

Duties of the Infantry during the Artillery Preparation. In connection with the artillery fire, the infantry in the position must observe the results of the bombardment and the leaders report their opinion upon its control.

Observation. The observation of the counter-battery fire, long-range fire on communication routes, and destructive fire on the interior of the position falls upon the artillery's ground observers and the aviation service. But the duty of observing the results of destructive fire on the enemy's first line is carried out with the help of the infantry observers. Each regiment must observe the front upon which it is to make the attack. Special attention is paid to the destruction of barbed wire entanglements and machine

gun emplacements. The interested infantry does not content itself with a passive observation, but must send out at night, or even in daylight, offensive reconnaissance parties. Their mission is to actually go into the enemy's first line, to ascertain its condition,

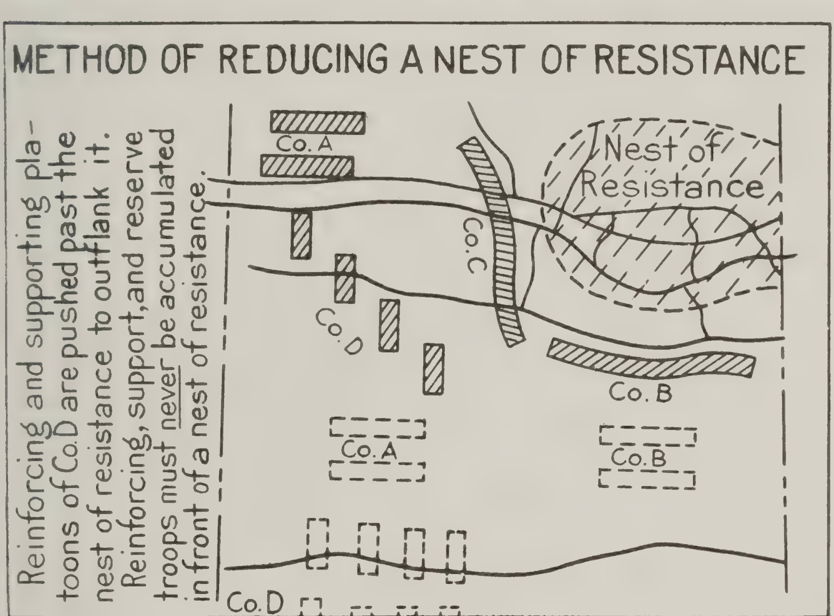


and to investigate the breaches in the hostile entanglements. The tactics of such a reconnaissance are the same as for a raid. The information gathered is sent to the division headquarters in the daily report of the intelligence officer or in special information reports.

Control. It is both the privilege and the duty of the infantry

commanders to state in their daily reports their opinion on the artillery preparation. If they do not express their exact opinion on the progress of the bombardment, they are liable to pay for their carelessness at the time of the assault.

Destruction of the Enemy's Position. The experiences of three years of trench warfare have given bitter proof that an attack against an insufficiently destroyed position will not only fail but will result in great losses. It is sheer folly to attempt an assault against undestroyed entanglements, or against a line in which the



machine gun posts have not been demolished. One does not oppose matériel with men. In trench warfare, the conquest of the ground is made by the artillery; the infantry follow up this conquest to occupy and to hold the ground. The essential condition for the success of an attack depends upon the proper destruction of the elements of a position by the artillery.

Plan of Battle. The plan of battle depends upon, first, the strength of the enemy, obstacles to the attacking troops, lines of defense, nests of resistances, barbed wire, etc.; and secondly, the mission of the attacking unit and the means at its disposal.

Strength of the Enemy. The Information Service of a division

has so many different methods of obtaining information and data of the enemy and his defenses that the assaulting troops can be constantly kept advised of the state of the hostile position. The regiment receives daily from the division headquarters an information bulletin, aëroplane pictures, and precise maps of the hostile lines. Upon these data the regimental commander bases his plan of battle. Comparisons of aëroplane pictures and maps are particularly useful. From all these data, the regimental intelligence officer makes pertinent extracts for the information of the battalion commander. Copies of the different maps are distributed by the battalion and company commanders to their officers and noncommissioned officers in order that they may have a better knowledge of the hostile position for the attack.

Mission. The general plan of battle is issued by the division commander. Based upon the terms of this order, the Colonel, Battalion Commander, and Captain issue detailed orders of their own plan of battle. The plan of battle of a small unit usually comprehends the following points:

Mission of the unit in the attack.
Front to be attacked, with definite limits.
Objectives, different lines to be taken, the last objective.
Disposition of the unit for the attack; formation, intervals.
Disposition of the unit in the parallels of departure before the attack.
The day (D) and hour (H) of attack.
Direction of the attack; compass angle.
Position of the leader.
Tactical relation with the neighboring units during the advance.
Use of specialists; machine guns, trench cleaners, etc.
Support of artillery during the attack.

Unit liaison during the attack:

With neighboring units and leaders (runners, telephone, signaling, carrier pigeons).
With the support artillery (detachment of liaison, observatories, and rockets).
With air service (rockets, signaling, Bengal fires).
With balloon service (searchlights).
Equipment for the attack.
Supply of ammunition and water; advanced supply points.
Evacuation of the wounded; dressing stations, routes of evacuation, auto ambulance points. Also, routes of evacuation for prisoners and assembling points for same.

This plan of battle is so drawn up that it may be executed any later day that may be designated in the order for the attack.

Preparation of the Men for the Attack. The work of fitting their men physically, professionally, and morally for the task before them devolves upon the leaders of all ranks. By a system of relief, the men of the garrison get short periods of rest behind the sector to shake off the atmosphere of the trenches. Continuous instruction of both men and officers in the basic principles of fighting should be carried on at all times. The moral training of the men depends to a great extent upon the officers. The leaders, by example and encouraging words, should instil into their soldiers that fighting spirit which makes for success in battle.

II. THE ASSAULT.

Formations for the Assault.

Disposition in Depth. The assault has for its purpose the capture of the first hostile line, that is to say, the crossing of "No Man's Land" and penetrating the enemy's position. The assault is only the beginning of the combat. When the breach has been made in the enemy's first line, the assaulting and reinforcing troops must continue the fighting in the interior for the conquest of the position. The direct object of the assault is to open the way for the attacking troops into the position. The attacking troops are disposed in depth in a series of echelons, so that during the advance each echelon is brought into the battle at the proper moment. This rule of formation in depth is followed without exception by every unit of whatever size.

The regiment forms with one or two assaulting battalions, and two or one battalion behind in reserve. The battalion has three or, better, only two assaulting companies and one or two companies with machine guns, in the second echelon as support. The company may have three, but more usually two, assaulting platoons with one or more reinforcing platoons in the second line.

Waves. The successive echelons have received the name "waves." This designation is expressive but not clear, and causes mistakes.

First, waves may be formed by different dispositions: in deployed line or in line of small columns.

Secondly, the waves are not always composed of the same strength of troops or units, and consequently are not of the same

disposition. The battalion commander will designate his first assaulting company as his first assaulting wave. Similarly, the company commander designates his assaulting platoons as the first wave; and the platoon leader, his first skirmish line as the first wave of the platoon.

Lastly, the real significance of the term "wave" lies in its application to the formation of the departure of the attack and during the first part of its advance into the interior of the hostile position. As soon as the assaulting echelons are held up by nests of resistance, they are obliged to halt while neighboring echelons on both flanks continue the advance. Also, reinforcing units will come up from behind to outflank such a nest. As soon as such a condition arises within the enemy's position, the disposition of the troops in waves is lost and the fight is continued in the best formation possible under the circumstances.

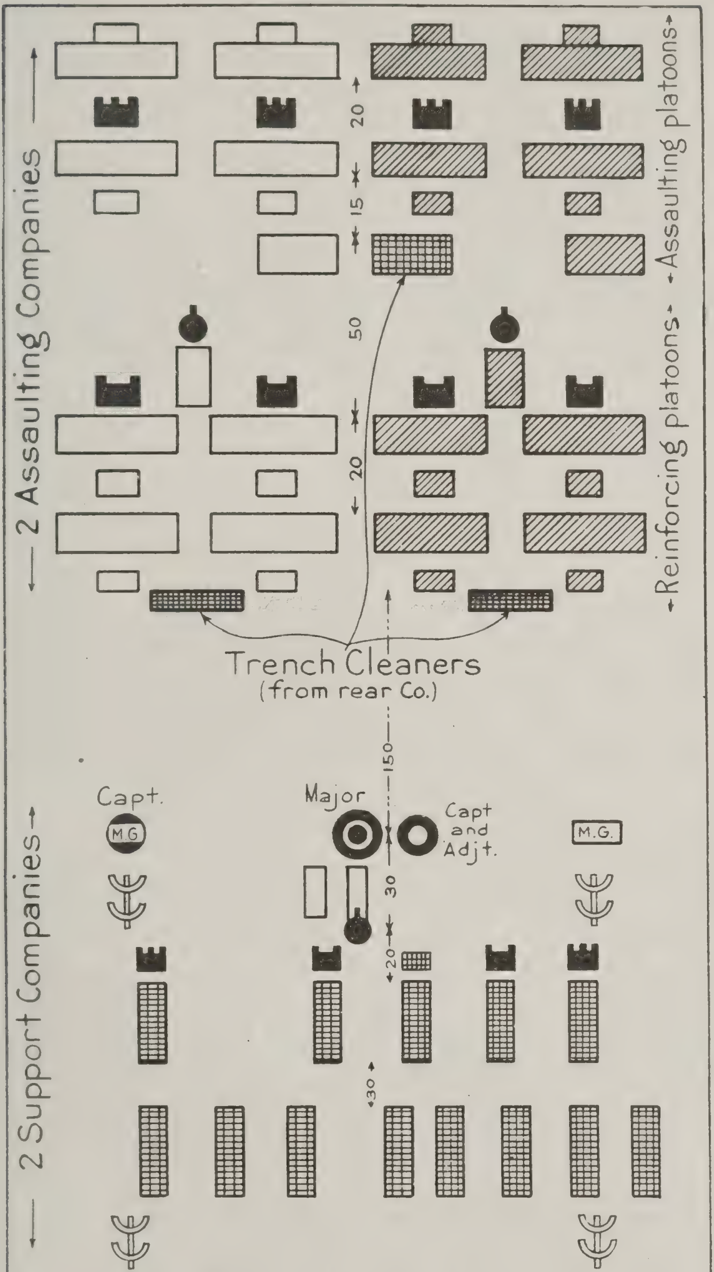
Formation of an Assaulting Battalion.

Assaulting Companies. In an assaulting company, a certain number of platoons are placed in the first or assaulting line, and the rest in the second line as reinforcing platoons.

The assaulting platoons deploy usually in two lines of skirmishers, the different specialists being assigned to places in these lines depending upon their functions in the attack. The line of assaulting platoons is known as the line of combat. A third line of grenadiers follows closely behind the assaulting platoon, and may be called a part of it. These grenadiers are furnished by the reinforcing platoons and are known as trench cleaners. Their function does not begin until the hostile line is reached, and it is to clear out the trenches of the first line of the enemy while the assaulting troops continue their advance in the open ground.

The reinforcing platoons are either deployed in lines of skirmishers or lines of small columns. These platoons constitute the line of reinforcement and follow the advance of the assaulting platoons at a distance of about forty to sixty yards. The machine guns detailed to the assaulting companies by the chief of battalion are placed with the reinforcing platoons and are usually carried on the flanks.

Considering the battalion as the assaulting unit and adopting the term "wave" to designate each platoon, we may say that the company of the first echelon of the assault is disposed in two



A Battalion Attack Formation
(Distances in Yds.)

waves. The position of the captain is in front of the second wave between the two reinforcing platoons. His liaison group remains with him.

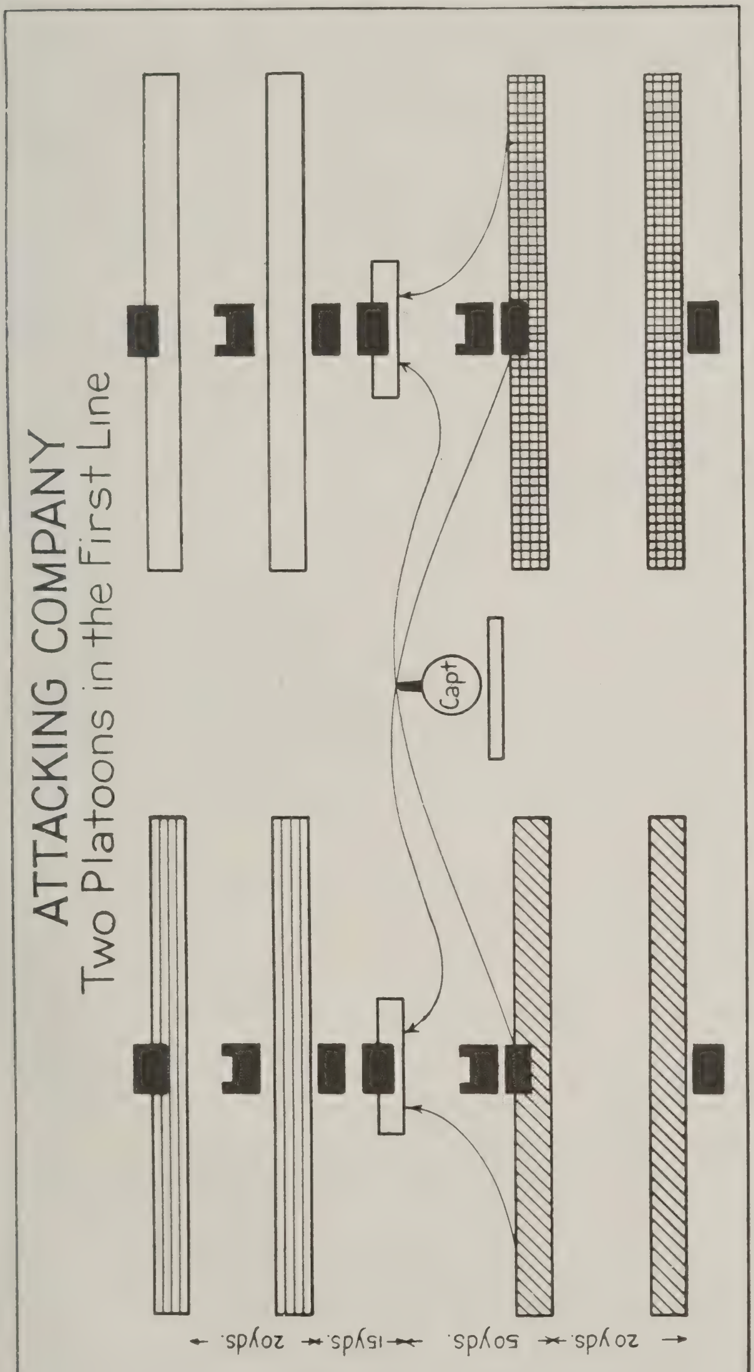
Supporting Companies. The supporting companies of an assaulting battalion constitute the second echelon. These companies, also, are formed in two waves. These waves are formed like those of the reinforcing platoons of the assaulting company, either in deployed lines or in lines of small columns. Usually the battalion has two companies in the first line and two in the second line. In other words, the battalion carries out the assault in two echelons of two waves each, the distance between the two echelons being from 200 to 300 yards.

In rear of the support companies and following their advance, are the remaining machine guns of the battalion and the 37 mm. platoon.

The position of the battalion commander with his liaison group is directly in front of the second echelon and between his support companies.

Disposition of Assaulting Battalion in the Departure Trenches. We have seen that for an attack the ground is specially organized for this purpose and the attacking troops are disposed in *successive parallels* or *places d'armes.* Usually this disposition is as follows:

The *two waves* of the assaulting companies are placed in the first and second parallels, which under ordinary circumstances will be the fire trench and cover trench of the first defensive line. *Consequently*, the different lines of each wave will occupy the same parallel, but at the moment of the assault the successive departures of the lines will permit them to automatically gain the necessary distances to separate them in the advance across "No Man's Land." *For example*, let us assume that there are four lines (this is the maximum) placed in one parallel. The men are numbered from 1 to 4 in successive groups of four each. Each No. 1 man belongs to the first line; each No. 2, to the second line, and so on. The distance between similar numbers in the parallels is about four paces, giving the proper skirmish intervals to the line. At the given signal of the leader of the line, the No. 1's go over the top. The No. 2's follow at the prescribed distance ordered or at another signal given by their leader. The other lines follow similarly, so that the assaulting troops have the regulation interval in line and a prescribed (not always regulation) distance in depth.


ATTACKING COMPANY
Two Platoons in the First Line
Capt
20 yds.
15 yds.
50 yds.
20 yds.

The two waves of the support companies are placed in a third parallel or *place d'armes*. This third parallel is usually an intermediate trench, or special work, executed for this purpose, located between the first and second defensive lines.

Machine guns and 37 mm. guns are located on the ground in relation to their places in the advance during the attack.

The battalions which are kept as reserves according to the plan of battle of the sector commander, are disposed in *places d'armes* organized behind the parallels of departure. The colonel and his headquarters occupy a command post directly behind the assaulting battalion from where he can witness the launching of the assault and the crossing of "No Man's Land."

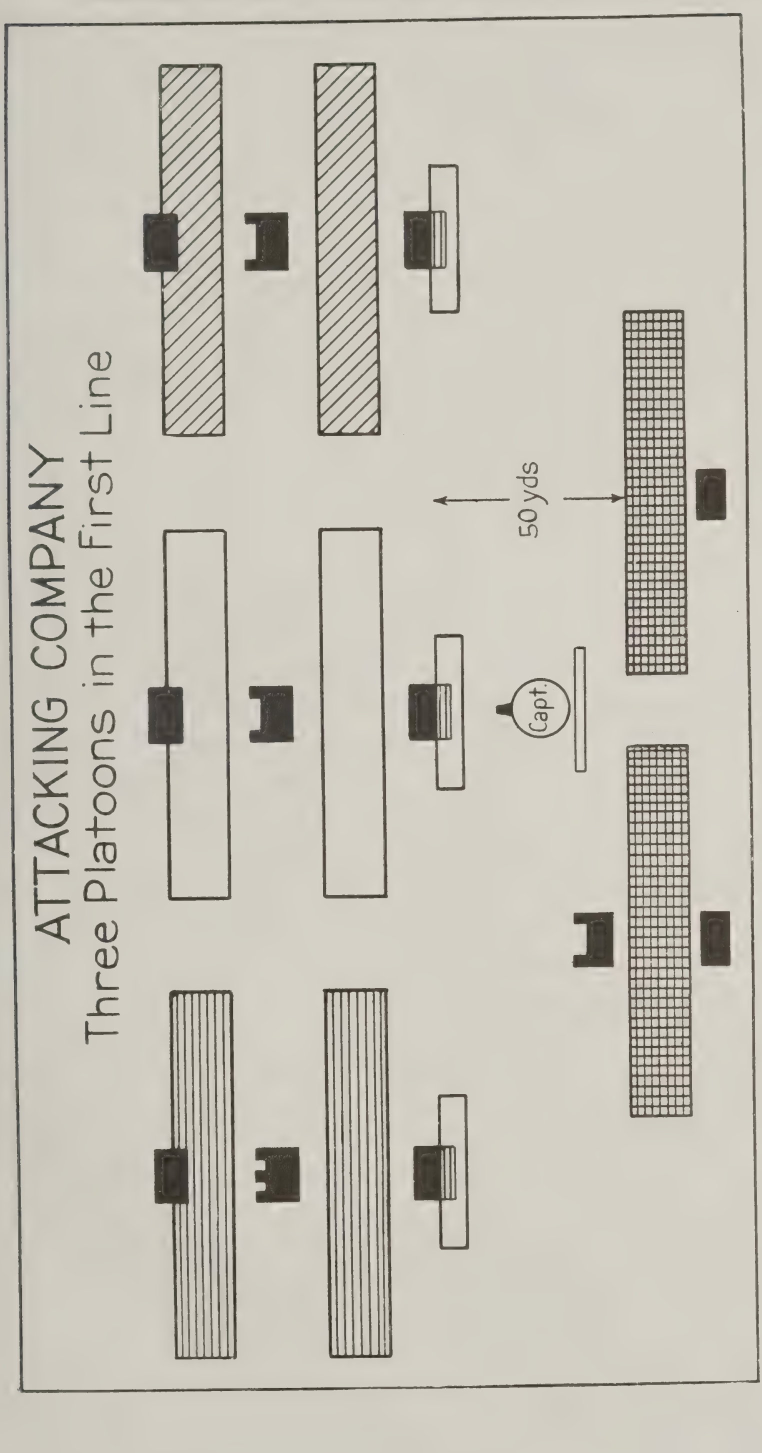
Order of the Attack. The attacking troops take the disposition that has just been explained some days before the attack. This disposition is laid down in a paragraph of the Plan of Battle. Each leader of an attacking unit, with a map of the ground on which his area is specially outlined, must study his disposition on the ground previous to the arrival of his troops. Besides this, the leaders must pay special attention to the hostile position, verifying the direction of the attack, and identifying the successive objectives and the nests of resistance that will be encountered.

When the general who is in charge of the attack judges that the artillery preparation is sufficient, that the supply systems for the attack are properly organized, that all is ready and, in short, that the psychological moment has arrived, he gives his order for the attack.

Based upon the divisional order for the attack, the colonels, battalion commanders, and captains issue their own orders. The difference between the plan of battle and the order for the attack lies in the fact that the latter fixes all the details of execution of the general operations laid down in the former. But also, the order for the attack contemplates the first measures to be taken as soon as the assault is carried out, especially the extension of the liaisons (telephone lines) and communications (boyaux) from the first parallel of departure up to the enemy's position.

The order for the attack contains precise details of the following points:

Exact hour of the attack; or signal rocket for the same.
Details of the successive objectives; different resistances that will probably be encountered.


ATTACKING COMPANY
Three Platoons in the First Line
50 yds
Capt.

Time-table of the moving barrage and the rate of its advance.
Prolongation of the telephone lines; particular wires to be extended.
Prolongation of communications; boyaux to be built at night across "No Man's Land"; units detailed for this purpose.
Supply of ammunition and water in the captured position; points of distribution.

Departure of the Assault [The hour (H)]. We have now arrived at the most important and critical moment of the battle, the hour (H) of launching of the assault. A few minutes before the hour (H) the men take the places assigned them in the parallels with strict orders to remain there. Bayonets are fixed on the rifles. Useless movements and noise of any kind are prohibited. Each man holds himself in readiness awaiting the signal of his immediate chief. Each chief of unit himself ascertains that his men are in readiness and in good condition for the assault. He sends all wounded back to shelter. The leader must impress his men with the confidence that he knows his duty, that he has foreseen and is prepared to meet all circumstances of the coming battle. The value of troops at this moment depends upon their leaders.

Support Artillery. During the time just preceding the hour (H) all the artillery which does not execute counter-battery fire is employed to protect the assault. A part of this artillery is given to each of the assaulting battalions as support artillery. Liaison and observations detachments are sent by this artillery to the infantry battalions to which they are attached. These detachments have the same composition and rôle as explained in the defense of a position.

The artillery support holds under its fire that part of the hostile line assigned to its infantry battalion. A violent fire is especially directed against the enemy's first line, the objective of the assault. Protected by this fire, the assaulting battalion moves forward. For a few moments after the launching of the first waves over the top, this fire remains on the enemy's first line. The protective barrage is then lifted and is established on the hostile second line, where it also remains for a certain time, according to the barrage timetable, and so on.

Departure of the First Echelon (Assaulting Companies). At the precise moment or signal the first wave of an assaulting company jumps out of its parallel of departure, the different lines of which it is composed being formed as previously explained. In a

similar manner, as soon as the first wave is launched, the second wave goes over the top of its parallel. All the different lines of the different assaulting companies advance straight to the front towards their first objective. The rate of advance, although not a run, is as rapid as the circumstances of the torn up ground of "No Man's Land" will permit, at the same time maintenance of the formations being paramount. Success depends upon the proper location of the specialists in the formations of the waves, and this order must not be lost in the confusion that results from too much speed.

The result is that all the lines of the assaulting companies start almost at the same time from the two parallels of departure, and with shorter distances between the lines than that called for by regulation. This formation is not a drawback, but, on the contrary, works to better advantage. The first and most important thing to avoid at this time is the defensive barrage of the watchful enemy. This is established as soon as he is aware of the assault. If the reinforcing line follows closely behind the line of combat, it has a better chance of passing the danger zone before the enemy's barrage is established. A company caught under the enemy's barrage will lose, on an average, fifty per cent of its effectives. Also, the assaulting companies must arrive in the first hostile line as quickly as possible behind their own barrage. The assaulting platoons, who set the pace, should arrive there almost "as soon as the barrage lifts." Troops that arrive at this opportune moment will surprise the enemy in his shelters or in the act of taking his place on the firing line. It is better to risk losing a few lives by your own barrage than to give the enemy time to man his first line.

Finally, the regulation distances between the different lines and waves will be attained during the progress after passing the enemy's first line.

Departure of the Second Echelon (Supporting Companies). When the first echelon, or assaulting companies, have crossed "No Man's Land," the battalion commander usually launches the second echelon, or supporting companies. By this time, the battalion commander will have an impression of the assault, and the distance which separates the two echelons is at this moment the one usually required (200 to 300 yards). In order to avoid the enemy's barrage and to profit by any lull in his fire, the battalion commander chooses the exact moment for the departure of the second echelon.

Advance of the Reserves. As soon as all the waves of the assaulting battalion have penetrated the enemy's position, the reserve battalions of the regiment leave their *places d'armes* and move forward through boyaux to the first parallels of departure. In this position they await the order of the colonel to advance into the enemy's position to join the combat for its conquest. The colonel awaits the first report from his assaulting battalion before giving the order for the advance of the reserves.

III. FIGHTING IN THE INTERIOR OF THE POSITION AND EXPLOITATION.

Principle of the Fighting. The fundamental principle of the fighting in the interior of the position is that each attacking unit from the division down to the battalion receives a definite objective. This objective is usually an area containing the lines of the hostile position with precise flanking limits. The farthest line in the objective area must be gained by the units at all costs. Beyond this last objective, strong reconnaissance parties and patrols are sent to keep contact with the enemy.

Usually the attacking regiments, which carry out the struggle in the interior of the position, are assigned the mission to capture the third or covering line of the artillery. The continuation of the struggle beyond this line and the capturing of the enemy's guns is what is called "the tactical exploitation of the success." The troops that carry out this operation are the reserves of the division held out for this particular purpose. The plan of battle does not include orders for this action.

Details of the Interior Fighting. Let us follow an attacking regiment in its progress in the interior of a hostile position, and consider the use of the different echelons of which it is composed: assaulting companies, reinforcing companies, and reserves.

Assaulting Companies. The advance of the assaulting platoons regulates the advance of all the successive elements. These platoons, after crossing the first hostile line, continue their movement without hesitation. The rate of advance is, of course, variable with the difficulties of the ground and the strength of the hostile organization. For this reason it cannot be very rapid. The pace of the leading elements of the assaulting column is foreseen in the plan of battle (depends upon the strength of the enemy's position), and this becomes the rate of advance of the moving barrage. If no unforeseen and serious resistance is encountered, the assaulting platoons will be able to keep up with their protective barrage.

Sometimes, however, they may halt for a moment in their progress under cover of some shelter to regain their alignment.

As a part of the assaulting platoon comes the trench-cleaner detachment. The trench cleaners are armed with hand grenades and trench knives. Their function is to enter the hostile trenches taken and, profiting by the surprise effect of the attack, to vanquish the last resistance and to make prisoners of the defenders still in the dugouts. They pay special attention to picketing all entrances, exits, and shafts of dugouts so that detachments of the enemy cannot come out and fire into the rear of the waves that have already crossed. If the different lines of the hostile platoon are very far apart, the number of trench cleaners is increased, a detachment dropping off in each line.

As long as the assaulting platoons do not meet resistance, the reinforcing platoons follow the former at the regulation distance to avoid mixing of the different waves of the attack. If, however, the assaulting platoons suffer severe losses, and are unable to continue the progress, the reinforcing platoon, either by order of the captain or upon the initiative of its leader, moves up and reinforces the combat line. Its function then becomes the same as that of the assaulting platoon.

Again, if a gap should occur in the combat line, due to losses or extension of the front, the reinforcing platoon moves in that direction and fills the gap. In general, the tactics of the reinforcing platoon are always to assure continuity of progress by outflanking resistances that have stopped the advance of the platoon in front.

The machine guns attached to an assaulting unit follow and protect the flanks. When halted they fire on retreating hostile troops and on special points of resistance. Their special use, however, is against counterattacks.

Reinforcing Companies. The reinforcing companies, with the machine gun reserve and 37 mm. gun of the assaulting battalion, after they have penetrated the hostile position, follow the progress of the assaulting waves at the prescribed distance. They advance in line of small columns but make use of any cover that the ground affords to minimize losses from hostile fire. During this advance, their mission is to rally all the elements of the assaulting companies and push them forward; and also to watch out for the flanks, pushing out to protect them on their own initiative if necessary. But when the line of combat is held up by resistance the

supporting companies are maneuvered by order of the battalion commander. Naturally, the whole line of combat will not progress uniformly. Certain assaulting platoons will be held up by nests of resistance, while others in the intervals will carry on with less interruption. Reinforcing platoons and support companies are maneuvered to outflank such nests of resistance and to fill the resulting gaps in the combat line.

Let us take a concrete example of an assaulting company followed by a supporting company held up by a nest of resistance (a ravine, reverse slope, or woods strongly organized with machine guns) and follow the movements of the reinforcing platoons and supporting company. (Examine the diagram showing maneuvers against a nest of resistance in connection with the following explanation.) The first figure shows the formation of the four platoons of an assaulting company advancing in the interior of a position, followed by a supporting company. The 1st and 2nd are the assaulting platoons, and the 3rd and 4th the reinforcing platoons. The supporting company follows the double column of platoons. The second figure shows the 1st assaulting platoon held up by a nest of resistance with the 3rd or reinforcing platoon moved up on the right flank. Platoons 2 and 4 of the same company carry on, and this movement results in a gap in the line of combat between the 2nd and 3rd platoons. The third figure shows the 1st and 2nd platoons of the supporting company moved up in this gap, and the 3rd and 4th platoons acting as reserves. The nest of resistance is thus attacked from the front and flank and the continuity of the combat line maintained. When a nest of resistance is encountered the attacking troops must not accumulate in front, as this will multiply the losses. The line of combat will attack the front of a nest of resistance while the successive reinforcing and supporting waves maneuver against its flanks. The battalion commander will use all the weapons at his disposal as machine guns, 37 mm. guns, and rifle grenades to reduce the nest of resistance. If this method fails he will have to call on the artillery for help, but this necessitates a modification of the artillery barrage time-table.

Rôle of the Artillery during the Attack. During the attack the artillery carries out the following different fires:

Counter-battery fire.
Protective fire on the flanks of the attack.
Accompaniment or barrage fire.

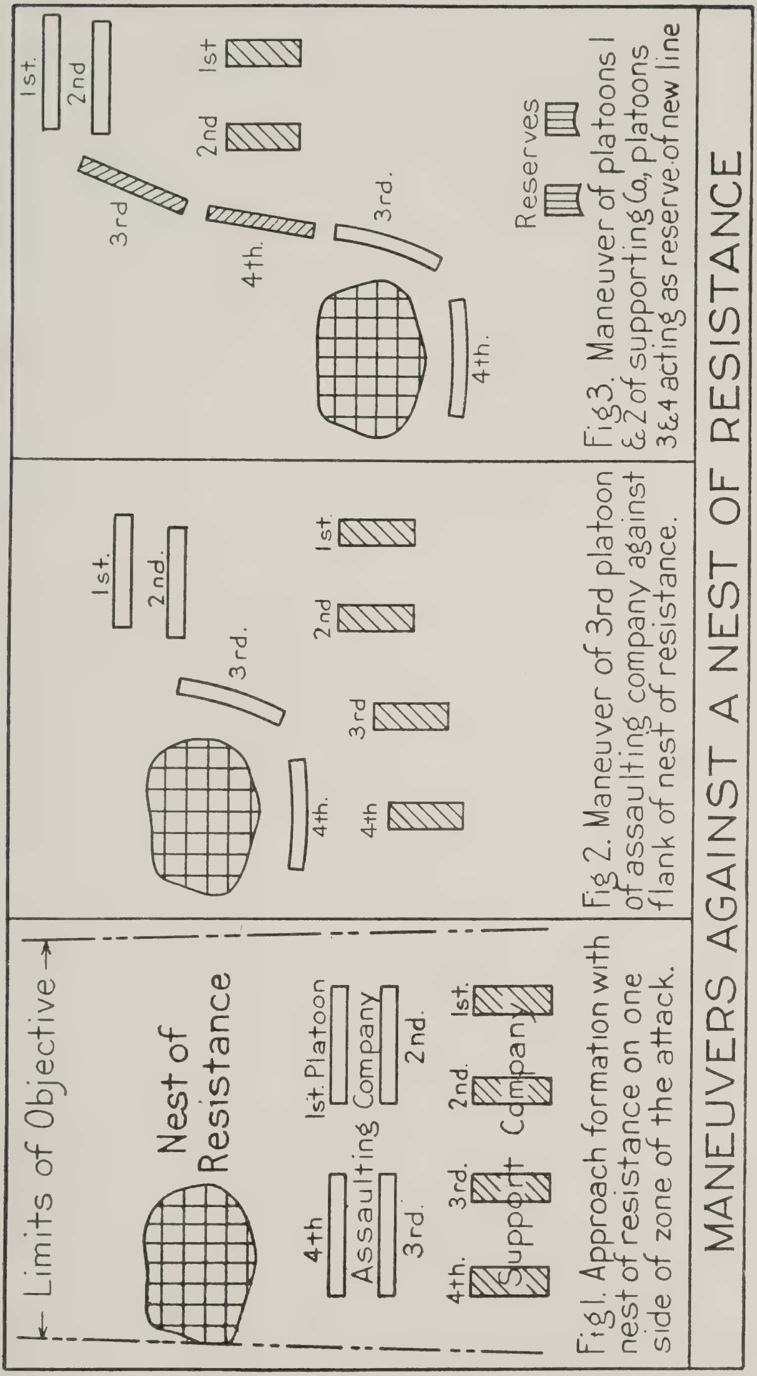


Fig 1. Approach formation with nest of resistance on one side of zone of the attack.

Fig 2. Maneuver of 3rd platoon of assaulting company against flank of nest of resistance.

Fig 3. Maneuver of platoons 1 & 2 of supporting Co., platoons 3 & 4 acting as reserve of new line

MANEUVERS AGAINST A NEST OF RESISTANCE

The first two fires are executed by a part of the artillery directly under the chief of artillery of the division, who in turn is under the control of the general.

The third kind of fire is executed by the support artillery, detailed to the different assaulting battalions as in the defensive organization. The action of this artillery directly interests each infantry chief of area, to whom are sent liaison detachments and observers (an officer, N. C. O's, and artillery orderlies). This third kind of fire is the only one that we will consider in detail.

Principle of the Accompaniment Fire. During the progress of the attack the support artillery establishes a moving barrage in front of the advancing infantry. This barrage travels by bounds. It remains for a certain time on each defensive line and at intervals between them so as to thoroughly sweep the intervening ground. The time-table, or rate of this moving barrage, is laid down in the plan of action of the artillery. The infantry leaders of course are acquainted with this time-table.

Other Means of Controlling the Barrage. The moving barrage may also be advanced successively by order of the commanding general according to information received from the leading elements of the assaulting battalion, from the artillery or aëroplane observers.

Calls may be made directly from the line of combat by rockets, or other means of liaison. With reference to the barrage there are two uses of rockets; one is for calling the barrage in the defensive, and the other is calling for an advance of the barrage during the attack. It may be remarked that it is impossible to call for a decrease in range of the barrage as this, of course, would be dangerous to your own troops. It is better to decrease the rate of advance of the barrage rather than to have it move too quickly and risk abandoning the infantry.

Lastly, the preceding means for controlling the barrage can be employed in conjunction. That is to say, a time-table for the barrage is adhered to during the first part of the advance when the positions of the hostile lines are well known, while during the last part, when the infantry's progress is not so regular and the ground is not so well known, each advance of the barrage may be called for by rocket, as each resistance met with is disposed of. If an assaulting battalion meets a resistance which it cannot reduce by its own means, it must call upon the support artillery for help. To do this, the artillery must halt its barrage and for an interval the time-table is not in effect. Such an emergency calls

for a special action on the part of the support artillery, and also for the intervention of any other artillery at the disposal of the general. This particular action of the artillery may be called for automatically by rocket or by the other means of liaison. The rôle of the officer and N. C. O. of the artillery liaison detachment is to give the artillery the precise technical information necessary in such a case to establish its fire on a nest of resistance. This action of halting the barrage and giving the artillery a new objective is exceptional and delicate to execute. As soon as the resistance is reduced, the time-table is resumed.

Liaisons During the Attack. The proper co-ordination of all the foreseen developments of the attack lies in a good system of liaison. There must be leadership liaison for the transmission of orders and reports, and infantry-artillery liaison for the proper co-operation of the two arms. The means of liaison in the offensive are the same as those considered in the defensive organization. The principle of their use is the same but made more difficult by the progress of the different attacking echelons. It is the duty of all leaders to foresee the establishment of liaison for the engagement in their plan of battle, and also for the prolongation of these means with the advance of the attacking troops.

The means of liaison are:

Telephone lines (for leadership in artillery. They are lengthened from the parallel of departure to the interior of the enemy's position.)

Signal communication (established from the enemy's position to a central point in the rear).

Rockets (precise signification of each kind laid down in orders).

Carrier pigeons (headquarters that are to carry these laid down in orders).

Detachment of special runners (essential to be established between all units).

Aviation. During the advance, a particular system of liaison is established with the air service. Each division has at its disposal a certain number of accompanying planes that fly low and follow the assaulting battalions. Their duty is to establish communication between the leading elements of the advancing infantry, and the artillery, and the commanding general. The infantry signal to these airplanes by means of rockets and Bengal fires, and the planes in turn communicate with the artillery and the commanding general by means of wireless.

BATTLE FRONT TRANSPORTATION

By

Lieut. Roger Haydock
Engineers Reserve Corps

The importance of roads in the conduct of war has been demonstrated often to marked degree from the time of the ancient races. The primary object of their great national highways was to facilitate the movement of troops rather than the development of commercial and social welfare. They saw that to maneuver successfully in strategical and tactical combinations it was essential that they have mobility, and maximum mobility could not be obtained without good roads.

Among the first authentic records of public highways are those of the Assyrians, built more than 1000 B. C. Those of the early Greeks were next; and later, the early Romans, the pioneers of military road building conducted them on a scale more extensive than those of any other nation.

The royal roads of the Romans were the main through arteries of travel; they were main military roads, and traversed all of the civilized portion of Europe and the northern part of Africa. Largely by these roads, Rome was able to hold the supremacy of the world since she could readily transport her troops to any section of the empire desired and there offer quick effective resistance. As the Roman Empire declined, we see a marked disuse of its roads until, owing to the growth of trees and bushes which were allowed to cover them, some became little more than bridle paths. When Charlemagne reorganized the empire, he realized the importance of these disused roads and commenced at once to restore them. During the wars of the Crusaders, and those which followed, we see a revival of road building operations, showing that they go hand in hand with military activity. The work on the roads was done mostly by the armies or by the people subjected.

In the present great world conflict, we have a vast amount of activity in road building. Immediately preceding every contemplated "push," extensive preparations are made, the size of which

vary in direct proportion to the objective sought. In the case of the battle of the Somme the Allied Staff had been making ready for months bringing up vast quantities of stores from Great Britain, which had been turned into a colossal arsenal. France, from the Channel to the Somme, was interlaced with a system of roads and railroads which alone made possible such an operation.

England is now using this network of highways in her military projects. France, too, has reaped the benefit derived from her extensive system of good highways; was it not those which made possible the magnificent stand at the Marne? Had it not been for these good roads, General Joffre could not have accomplished the wonderful work which delivered Paris from the hands of the onrushing enemy.

With three armies now operating on the front, it can readily be seen that in order to avoid confusion, a distinct section must be allotted to each. The fact that the organizations are separate and distinct permits each to build up an independent system of communications from the seaports to the established bases at the front without confusion or disorder.

RAILWAYS.

In order to get the immense quantities of stores up to the firing line, an elaborate system of railroads, roads, and cableways has been placed in operation. The American Railway Engineers have already undertaken to develop and perfect the system. The accompanying illustrations will show some of our locomotives, track-laying machines, and Engineers at work in France. The standard gauge track runs up as close to the line as safety permits. The contents of the trains are there removed and temporarily stored. The store yards, it is said, resemble the vast freight yards of Kansas City, Chicago, or some other large freight metropolis in this country. At that point the narrow gauge railway and the motor truck take up the work of transporting this never ending influx of materials to front line supply stations close up to the firing line. At numerous strategic points on these lines, auxiliary forces of able bodied laborers, known as the "Transport Workers Battalions," are posted. They are hurried to the terminals or other points when needed, supplying labor to assist in loading and unloading the freight promptly from the cars. To expedite the work at the terminals, large and highly efficient machines are used. (See Figs. 1 and 2.) The freight yards are so designed as to have a

loading and receiving platform on one side of the track and a road on the other, the advantage being that freight can be immediately transferred from trucks to motors and vice versa when these are available; otherwise it is placed at once on the platform and afterwards removed. The chief cause of freight congestion is delay in handling at the terminals and this must be watched with utmost care. Car shortage has also played havoc with the efficient delivery of freight, both in this country and abroad. It is therefore important to see that each car carries its maximum load, so that none of its space be wasted. It was announced recently by the War Board of the American Railway Association that in time of peace,

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Fig. 1. Unloading American locomotives in France at port of debarkation.

as much as 50 per cent of the space in box cars was wasted. In other words, it would appear that by careful packing and handling, the effective carrying capacity of a box car would be double that in time of peace. It was also shown that the losses sustained through the lack of cars could be materially reduced by lengthening the daily runs and increasing the speed of the trains. In actual figures, relating to this country, it was shown that by speeding up the cars five miles per day and loading them 10 per cent more than marked capacity, an equivalent of 515,000 cars would be obtained.

The reconstruction of the disorganized and destroyed railways of France was necessary, and it is understood that this work has

been placed in the hands of American railroad men. A complete reorganization and rebuilding is in progress: American trucks, locomotives and rails have been shipped abroad in large quantities. The locomotives are received crated in a knocked-down state at the port of debarkation, as shown in Figure 1. By efficient machine handling, they are rapidly assembled, and within a remarkably short time are speeding over the rails, carrying behind them the vast stores which are so needed at the front. (See Fig. 3.) The Canadian lumberjacks and our own boys from the forests of the great northwest are solving the problem of obtaining timber for ties, planking, sheathing, etc. Equipped with all the modern ap-

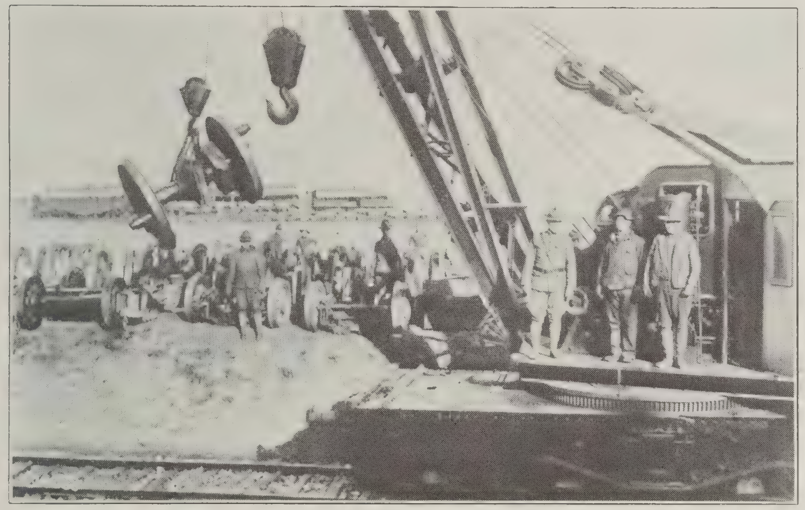

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Fig. 2. Assembling American locomotives in France.

pliances for lumbering, whole regiments of foresters are at work in the forests of the Vosges Mountains stripping that country of all the available timber. One of the machines used for expediting the work of handling and loading the cut timber on the cars is shown in Figure 4, while Figure 5 shows a type of tie-laying machine which is now used abroad to great advantage and in Figure 6 we have some Belgian Engineers at work on the construction of a railroad to a front line supply station.

The railroads may be classified roughly into two types: the standard gauge and the narrow gauge or "light railway." The design, layout, and operation of the former is carried out as in

standard practice, while with the latter much depends upon local conditions. The system as a rule is very complex, radiating in various directions from centers or terminals; at the end of the standard gauge lines it forms the connecting link between these and the trenches. The tracks are interlaced in order to give greater flexibility; any important points such as quarries, sand pits, forests, etc., where material is available are, of course, hooked up with the system, and usually you will find a line paralleling the front line trenches. Back of the lines, near the big gun emplacements, spurs are run off into the tunnels where the shells are stored for protec-

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Fig. 3. American-made locomotives assembled in France.

tion from the enemy's fire, as shown in Figure 7. Another entrance to this ammunition storehouse is seen farther up the hill, this is for use in cases of emergency. The rails of the narrow gauge weigh from 20 to 25 pounds per yard; they are laid on wood ties, although of late steel ties are coming into use to a considerable extent. Experience has shown that it is necessary to ballast the road to get the best results; for this broken stone, brick, slag, cinders, or gravel is used.

Small steam locomotives of the 2-6-2 type, weighing approximately 17 tons, are operated up to the point where the smoke and steam would betray their presence to the enemy. From that region

the trains are hauled farther forward by gasoline or electric locomotives, or by animal power and from there on the material is hauled by motor trucks or teams to the front line supply depots. Light cars, specially designed, drawn by dogs are used to some extent in certain sections. In Figure 8 we see a team of dogs hauling one of these vehicles. Many of the dogs are Alaskan "Huskies," from famous teams in the Klondike region. In the winter months they are used to haul sleds filled with ammunition to the firing line.

Fig. 4. Canadian lumberjacks at work in French forest.

The light railways were developed to relieve the highways of the brunt of the heavy traffic, leaving them free for the motors carrying light fast traffic. Experience has shown that this extremely heavy trucking is chiefly responsible for the excessive wear and tear on the roads; consequently, if bulk of this transportation can be borne by the narrow gauge lines it will do much towards solving the problem of maintaining the highways, which has become perhaps the most important problem of the highway engineer.

By comparing the carrying capacity of the average train with that of the average truck we can appreciate fully to what extent these railways relieve the highways. The train of six cars carries

approximately 60 tons, while the motor truck carries but 3 tons. The average train then is equivalent to a fleet of 20 motor trucks.

HIGHWAYS.

Experience has shown that a highly developed railway system is of little use to the community unless it be supplemented by a system of good highways, which facilitates the efficient loading and delivery at intermediate points. The railroad can reach only its various stations, and a slight accident will interrupt its traffic, but

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Fig. 5. A tracklaying machine at work.

with a good system of roads vehicular traffic can reach any point en route and be stopped only by the destruction of the road. Even England with her comparatively small area and tremendous network of railroads has found her roads, especially the main ones, of vital importance.

In the present war the motor truck, though a short-haul vehicle, has proved to be a valuable adjunct to the long-haul railway transportation, especially in transporting troops, artillery and material of all kinds. Motor trucks have been converted into armored cars, veritable swift moving forts. Patrol, messenger

service, ambulance corps and supply trains all use the motor as a means of locomotion, as does the commissary department for their field kitchens. In the past, operations of any magnitude have always been dependent upon the railroads, but recently the motor truck has been used to move large bodies of troops over distances as great as 100 miles. It is readily seen that the demand for good roads, kept in the best possible condition, is rapidly increasing, and that such roads are valuable assets to the community in times of peace, and in times of war become assets of incalculable worth. The modern military road in order to fulfill its mission for any

Fig. 6. Belgian Engineers at work constructing a railroad.

length of time, must be built like a modern civil highway. In other words, the terms military and civil roads are beginning to designate more nearly the same class of highway. Of course, we still have a temporary road built of dirt, cinders or corduroy, but these are used only in cases of emergency and must now be quickly followed up with some form of modern surfacing, otherwise the extremely heavy traffic will soon cut it to pieces. Modern military requirements for roads are very severe, and only those of the highest type can stand up under the constant strain imposed upon them. Like any other engineering structure the road must be properly

designed for the load which it must carry, and if this fundamental principle is overlooked the road, like any other structure, will fail.

According to the existing ordnance tables the heaviest field piece found in our army is the 12-inch howitzer, which weighs approximately 27,000 pounds; the front wheels taking about two-thirds of the entire load, or 18,600 pounds, while the remaining one-third is carried by the rear wheels. The wheel base is 18 feet, the gauge 7 feet 4 inches, the width of tires 8 inches, and tire shoes 12 inches. This gives a load of approximately 775 pounds per square inch exerted by the shoe, assuming that 1 inch of the circumference of the

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Fig. 7. Tunnel leading to shell-proof ammunition store-house.

wheel bears on the road surface. This is not excessive and is in keeping with loads used in current practice, consequently roads designed for such should be able to take care of army ordnance. Marked increases in the loads are anticipated in the near future, which according to the new "Manual of Portable Military Bridges" makes it necessary to design for a load of 38,000 pounds on one axle. (In the "Proceedings American Society of Civil Engineers," December, 1911, Henry B. Seaman, American Society of Civil Engineers, mentions, among some of the heavy loads which occurred on the streets of New York City, the case where cables weighing 84 tons

were carried equally on four wheels, the truck weighing an additional 6 tons; and girders weighing 65 tons were carried mainly on a long truck, the rear wheels of which were taking most of the load.) These loads are of course excessive, but bring out the point that the modern highway, properly constructed, has a good factor of safety.

It is of interest to note in this connection that an official report from the European war zone states that the heaviest ordnance (believed to include the famous 42 cm. howitzers, but known to include the 30 cm.), moved steadily to the front without serious interruption, even though some of the roads were unmetaled and

Fig. 8. Dogs hauling wagons on light railway.

deep in dust. Much repair work was of course necessary to keep the crown well shaped and free from serious ruts and holes. The damage done to these roads, however, was caused principally by fast moving traffic.

DESIGN.

The modern road is one whose wearing surface is capable of resisting a maximum amount of abuse with minimum maintenance repairs, and so built that when such repairs are necessary they can be made quickly and easily with least interruption of traffic. The

tractive resistance must be low, and at the same time it must offer good foothold for horses and afford a good grip for rubber tires. These requirements are of course ideal, but every highway engineer strives to obtain them as near as possible when designing.

The question of grade, curvature, and distance are also vitally important to the designer in civil practice who must consider carefully the location, foundation, drainage, width, nature of traffic and climatic conditions.

In military road building, however, many of these points must be sacrificed on account of the limitations imposed by time and

Fig. 9. Rebuilding a road in the Aisne District; note the corduroy base.

material at hand. The engineer in time of war must of necessity build as rapidly as possible, usually to meet the exigency of the moment; he should, however, bear in mind the fundamental principles laid down in civil practice, so that afterwards the road may be altered and improved to fit in with the general scheme of development.

The question of security or concealment is another important point which must be kept in mind when laying out a military road; it is advisable to take advantage of any available cover, such as the crest of a ridge, a wood, hedge, etc., in order to shield the roadway from the view of the enemy.

Military roads naturally follow the contour of the terrain as nearly as possible, to reduce the amount of cuts and fills. These take time to construct and if they can be avoided by making slight deviations in the alignment it is of course advisable to do so. The road will be lengthened, which is contrary to one of the fundamental principles of road building, but much time will be saved. It is to be expected then that at times excessive grades will be encountered, but it is far more desirable, from point of time economy, to have these few points where the steep grade will necessitate the use of extra hill horses, than to consume the time in making a large cut to

Fig. 10. French Engineers reconstructing regained roads.

reduce the grade. Later on, when time permits, these high grades can be reduced by cuts and fills.

Low grades are to be desired and the engineer should strive to attain this desideratum as much as possible. This, too, can be done sometimes by a slight change in the alignment. Generally grades should not be greater than 4 to 5 per cent. No hard or fast rule can be set for determining the gradient, which depends entirely on the material used in the road and upon climatic conditions.

Roads built of material which offer a good foothold for the animals and grip to the tires can have grades as high as 8 and

even 10 per cent, while those of smooth surface, such as asphalt or bituminous macadam, should not have a grade greater than 3 per cent; nor should those roads in northern countries or in the mountain districts, which are subject to much ice and snow, have steep gradients.

Curvature.

The question of curvature is also one which must be considered. Sharp curves should be avoided wherever possible. The governing feature in determining the radius of a curve, exclusive of local

Fig. 11. Belgian troops rebuilding their roads.

conditions, is the length over all of the animal-drawn teams and the width of the road. The four-line and six-line teams are the most common type used in military operations, their approximate allover dimension being 40 and 50 feet, respectively. A 12-foot road with a curve having an inside radius of 100 feet will keep vehicles of this type on the paved area. By increasing the width of the road at the turn, the radius of the curve can be materially decreased. Although it is not advisable to reduce the radius less than 50 feet, there are cases where army transportation has been taken around curves of 25-foot radius without encountering serious diffi-

culty, by increasing the width of the road on the turn to about 24 feet. The road should be banked on the outside edge of the turn in order to make it safe for rapidly moving vehicles.

Width.

Up to the advent of the modern motor truck a road 14 to 16 feet in width gave sufficient clearance between passing teams. Now, however, with trucks as wide as 8 feet, it is necessary to increase the width to 18 or 20 feet in order that traffic may pass with safety and not be compelled to run off on the shoulders. Where

Fig. 12. French Engineers in Alsace, making use of an adjacent quarry and sand-pit.

a one-way traffic system of highways is developed, the width of the road metal should be cut down to 8 or 10 feet. This system, however, is feasible only where the traffic is well regulated.

Crown.

In order to get rid of water falling on the roadway as quickly as possible, the surface is shaped or crowned. Crowning is done in two ways, viz: by circular or parabolic arcs or by the intersection of planes. Care should be taken not to have the crown too great or it will be the source of much inconvenience and even danger

to the traffic. Earth roads require more crown than pavements of the improved types. The usual crown given to an earth road is about 1 inch to the foot; gravel roads are given about $\frac{3}{4}$ of an inch; waterbound macadam $\frac{1}{2}$ to $\frac{3}{4}$ of an inch, while bituminous roads are given $\frac{1}{4}$ to $\frac{1}{2}$ inch per foot, depending upon the finish of the surface. Generally speaking, the smoother the road surface the flatter the crown.

CONSTRUCTION.

Drainage.

In highway construction water, in one of its forms, is usually regarded as the most active destructive agent. Provision must therefore be made for an adequate system of drainage, which will remove the water immediately when it falls on the surface or gets under the road. Drainage is divided into two classes: Surface and subsurface. The former consists of the crown and side ditches, which will usually be all that is necessary in military work except where the road passes through low wet ground. The best side ditches are those of the wide V-shaped shallow type, of sufficient depth to materially lower the level of the ground-water under the road, but not deep enough to be dangerous to traffic. They should be made as a continuation of the shoulder and ordinarily be about 12 to 14 inches in depth. A road grader can be used here with excellent results.

Subdrains are placed only when the nature of the soil requires, their purpose being to get rid of the ground-water or to lower it to such an extent that the road will have sufficiently firm foundation to bear the traffic imposed upon it. They are usually of stone, log, or tile construction, and should be placed under the side of the road from whence the ground water is apt to come, but in extreme cases they may be placed under each side of the road.

Foundation.

Too much attention cannot be given to the preparation of the foundation, for upon it the ultimate success of the pavement depends. If it fails, the finished pavement will eventually fail just like any other structure whose base is weak. The engineer will find the time spent in shaping up and rolling the subgrade will be amply repaid when heavy loads are applied, for it seems that these loads are always able to locate, with remarkable accuracy, these weak points. Foundations are of two kinds. natural

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Fig. 13. Rebuilding shell-wrecked roads in France.

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Fig. 14. Main street, Vancourt, devastated by shell-fire.

and artificial, their mission however is the same, viz, to distribute the load to the subsoil. The natural foundations, as the name implies, are those composed of some kind of soil such as clay, shale, loam, sand, or gravel; they are the usual type of military roads. The most common artificial foundations are large stone, broken stone, bituminous concrete and concrete; as a temporary expedient, brush, planking and logs are employed where the ground is low and poorly drained. The low flat ground of Flanders has made it necessary for the Engineers to resort to the latter methods quite extensively. The "Corduroy" is quite a common form of con-

Fig. 15. Bridge wrecked by the Germans when they were forced to retreat through Soissons.

struction in this section. Figure 9 shows the French engineers at work rebuilding such a type road, which was completely wiped out during a German bombardment in the Aisne region.

TYPES OF ROADS AND PAVEMENTS.

Earth roads of course require much attention to keep their surface smooth and well crowned, for depressions in the surface hold water, which means eventually the destruction of the road by creating soft spots that soon become dangerous holes. Metaled

roads are used to cut down this continual maintenance. The most common types of the modern road are broken stone (water-bound and bituminous macadams), slag, cinder and shell; of these, stone roads of course are best. In their construction certain vital points should be carefully watched. The stone trench should be well cut, and the subgrade carefully prepared. The stone should be graded, placing the larger stone on the bottom, being sure to "key" each layer by careful rolling, before the next is placed. The stone should not be allowed to "spread" at the sides. This is prevented by carefully compacting the shoulders. In Figure 10 we see the

Fig. 16. Bridge in Flanders, 120 miles in length, of ponton and trestle construction.

French engineers relaying the lower course of a stone road which had been completely destroyed by shell fire in the Aisne region. In the cities and towns these roads give way to other types of pavements such as asphalt, wood block, stone block, brick and concrete. The latter two are also used to a considerable extent in the rural district. Modern construction demands that concrete foundations be laid under all of these improved types of pavements.

Labor and Materials. In army work labor will be plentiful, but modern plant equipment and the best material will in all probability be scarce. Picks and shovels, with possibly wheelbarrows,

will be the principal tools used, although for extensive work it is advisable to obtain some plant equipment, such as plows, wheel or drag scrapers, graders, etc., which will greatly facilitate the work. The teaming will usually be done by animal-drawn vehicles; although for long hauls over good roads it would be more economical to use motor trucks. In Figure 11 we see the Belgian troops putting their roads in condition for the Allied Spring Offensive.

The question of road material is one that requires careful study on the part of the engineer in order to utilize the material at hand which is best suited for his needs. If the road passes near a stream this should be explored for gravel which with the addition of a little binder compacts fairly well, as does good pit gravel which is frequently obtained near the site. In the shell districts where good road material is usually scarce, a fair road can be obtained by confining the shell in a well-shaped and solidified trench. The surface, however, grinds rapidly into dust and should be treated with asphalt, oil or tar for protection. If outcroppings of rocks, ledges, or bowlders are encountered, these should be utilized by developing quarries; and if the nature of the work demands, light railways should be run from them to the operation, in order to hasten the work. In Figure 12 we see French soldiers at work removing gravel and stone from a quarry and sand bank adjoining a highway they are constructing in Alsace. Shells and heavy traffic have combined to wreck the roads leading to the fighting front; as a consequence corps of laborers and soldiers are at work constantly repairing these highways; Figure 13 shows a gang at work in the mountainous district. The shell fire is not confined strictly to open country; in Figure 14 we see with what the engineer has to contend in order to keep open the streets which pass through a town.

BRIDGES.

An army to be mobile in the full sense of the word must be able to effect a crossing whenever a stream blocks its path. The success or failure to cross such a stream has often been the deciding factor in a campaign. History shows us that many an able general's victorious march has been checked by his inability to cross a stream at the crucial time and, conversely, that many an army has been saved by interposing a river between it and the pursuing enemy. In Figure 15 we see an illustration of a bridge, wrecked by the Teutons when they were forced to retreat over the river which flows through the town of Soissons.

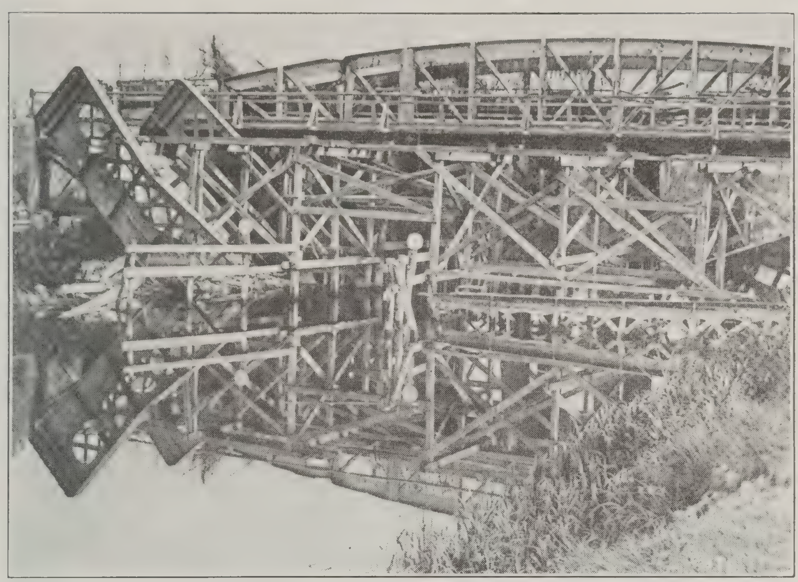

Fig. 17. Destroyed steel bridge replaced by another, in the Aisne Sector, by French Engineers.

Fig. 18. Temporary structure of the Allies thrown across span which was destroyed by the retreating Germans.

Realizing the great importance of being able to cross streams, all modern mobile armies are supplied with ponton and portable military bridge trains so that they are not dependent upon improvised makeshifts hastily constructed at the site.

The ponton bridge consists of a series of floating supports in line, upon which is laid a system of floor stringers, or balks, over which a plank deck is placed and held in position by side rails lashed at intervals to the outside balk. Special trestles are used at the end bays and where the water is too shallow to float the ponton. In order to carry on the offensive in Flanders, the French

Fig. 19. Bringing up the boardwalk sections from the rear.

and British have used the ponton bridge extensively: in Figure 16 we see a bridge of ponton and trestle construction, the length of which is 120 miles, built across the mud flats of Flanders, through which the French and British struggled with their heavy field-pieces. Note the double roadway, one for vehicles and the other for foot travel.

The *portable military bridge trains* are provided with the necessary cut timber, trussed wood stringers, I-beams, plate girders, latticed steel trusses and accessories which permit the building of a bridge more or less permanent than the hastily improvised structures. These portable bridges are standardized and many of their

parts built up in the depot or fabricated in the shops. The framing of the timbers is as simple as possible; joints are square and connections are made by means of driftbolts, so that all operations are cut to a minimum. Metal trusses are built up as far as possible, so that the structure can be erected with little more than the addition of a few bolts, which later as time permits can be made permanent by replacing them with standard rivets.

During the present European war the extremely heavy loads hauled over the highways have brought about important changes in the design of our portable bridges. The following data were ob-

Fig. 20. Belgian soldiers building boardwalks over shell holes.

tained from the revised "Engineer Instruction Manual No. 5," which is about to be published. The design provides for a live load of 19 tons or 38,000 pounds on one axle with 6-foot wheel gauge, or a live load of 100 pounds per square foot over a 12-foot roadway.

Bridges of the I-beam type are made in various lengths, the longest unspliced beam being 45 feet, consisting of three girders each made up of two 20-inch 65-pound I-beams permanently fastened together. The weight of one girder is approximately 4 tons. Longer spans, up to 60 feet, are obtained by splicing two short spans to give the desired length.

Plate girder bridges are generally used where spans of 45 feet and upwards are necessary. By splicing combinations of sections, which are 22 feet 6 inches in length, girders in multiples of these lengths can be formed up to 90 feet. These bridges are of the through type with floor beam, stringer, and plank floor construction. All the material required for such a structure can be transported on four 5-ton trucks and four 5-ton trailers. The time required to erect such a span is 17 to 26 hours, depending on whether a derrick truck is available.

The lattice steel truss is also used in the same way as the girders,

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Fig. 21. Repairing the boardwalks after the battle of Flanders.

the length of section and the construction of their floor system being the same. The main advantage of this type over the girder is that of weight, the lattice being about 20 per cent lighter.

The French engineers during the present war are following up their reconstruction work close to the front line with remarkable rapidity; Figure 17 shows a steel bridge replacing one destroyed by the Germans in the Aisne sector. The faith of the French in the success of their armies is shown by the fact that most of these replacements are permanent, not temporary.

In military work it is usually imperative that the bridge be

built at once, in which case a temporary structure is hastily thrown across the stream from materials found at hand. These bridges are constructed for a special and immediate purpose and are not required to fulfill all the conditions of ordinary bridges.

Figure 18 shows a stone bridge partly destroyed by the Germans when they retreated before the French offensive; an attempt was made to wreck the whole bridge but it was not successful. A temporary wooden latticed trussed bridge, a type quite commonly used by the continentals, was subsequently thrown across the break to allow the Allied advance.

Fig. 22. Boardwalk behind screen of vines.

Time is the paramount element in stream crossing, the attacker must succeed in deluding the enemy as to the point of crossing, so that he can obtain a foothold on the opposite shore and there acquire through his combative ability the tactical, technical and moral superiority. It is therefore seen that bridges of this type are of vital importance to the mobility of the army. The selection of the type of bridge most suited to fit the requirements of the site, and the materials at hand, is also an important point which must be considered by the engineer officer in charge in order that the quickest results may be obtained. The most common types of rough timber bridges are the simple pile trestle, the single and

double lock spars, the king and queen post, and the truss bridges such as the lattice, Howe, bow-string triangular and others of simple construction.

In selecting the site the approaches should be considered, for it has been said that the real work begins when the approaches are commenced. To show that this is sometimes true, in building one of the bridges over the Aisne it was necessary to construct a road 200 yards long in order to make a satisfactory approach. Some 2,000 fascines had to be constructed and hauled to the site along with all the available road metal in the neighborhood.

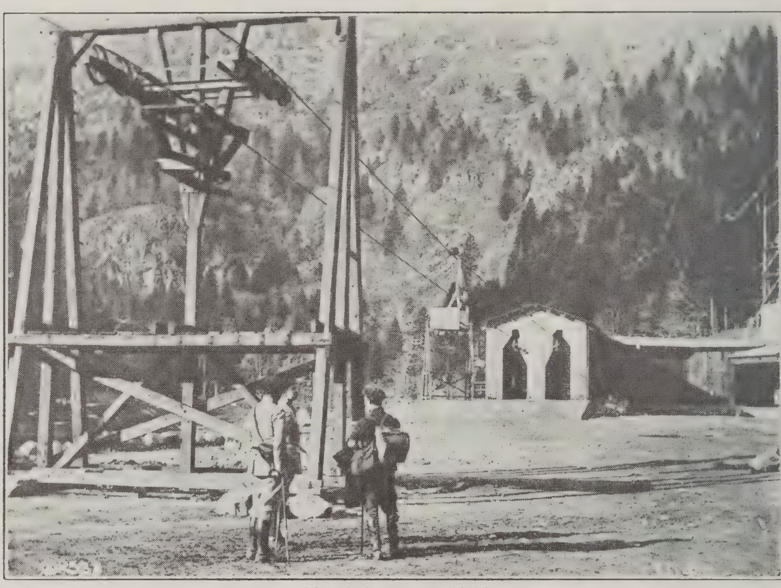

Fig. 23. A cable railway in the Vosges Mountains.

Organization is another very important factor in efficient work, the various details should be thoroughly instructed in their duties and kept busy during the entire time. That part of the work which is apt to be delayed should be pushed energetically and if necessary the most efficient men should be assigned to this detail.

The work of the engineer not only consists of building bridges but also includes determining whether certain existing structures are sufficient to withstand the load of the passing army ordnance. In order to aid in determining quickly and with accuracy what size timber joists and wood and steel stringers are necessary for

various loads and spans, the following tables will be found to be of value. These are used in the office of the Watson Engineering Co. of Cleveland, Ohio, and it is through the courtesy of Mr. Wilbur J. Watson, president of the company that they are here published. (See Plates 1, 2 and 3.)

Plate I (Curves, showing size of timber joints).
Plate II (Curves, showing size of wooden stringers).
Plate III (Curves, showing size of steel stringers).

BOARDWALKS.

Boardwalks, during the present war, play an important rôle in the system of transportation on the battle front. Starting well back of the front line trenches, at the point where vehicle transportation can no longer be continued with safety, these apparently unimportant lanes of communication are the means by which the majority of supplies are brought right up to the fighting men. Trenches which would be otherwise impassable with mud and water are transformed into arteries of communication by the means of the "duck" boards. Whether these walks are on the surface or in the trenches is of no consequence, they still continue their function as the final link in the transportation chain. They are made up in standard size sections behind the lines, usually at the dumps or at the workshops, from which they are conveyed to the front by light railway or wagons (see Figure 19). The standardization of the section is an important feature in the construction of these walks, since a far greater flexibility is thereby obtained. The usefulness of the board walk is not confined to the flooring of trenches alone, it extends even farther than the first line trenches. Owing to the effect of the high explosive shell, it is almost impossible for attacking infantry to make any kind of headway across "No Man's Land," unless provided with sections of boardwalks to bridge the shell holes. In Figure 20 we see Belgian soldiers building such a walk, over which troops and supplies can be transported. The mud encountered on the flats also necessitates building and maintaining a system of boardwalks to expedite the advance of infantry; in Figure 21 we see the Belgians making repairs to their walk after the great battle of Flanders. Whenever a line of communication, whether railway, road or boardwalk, is apt to be seen by the enemy, means should be taken to hide it, especially if it is to be used for the purpose of transporting troops or sup-

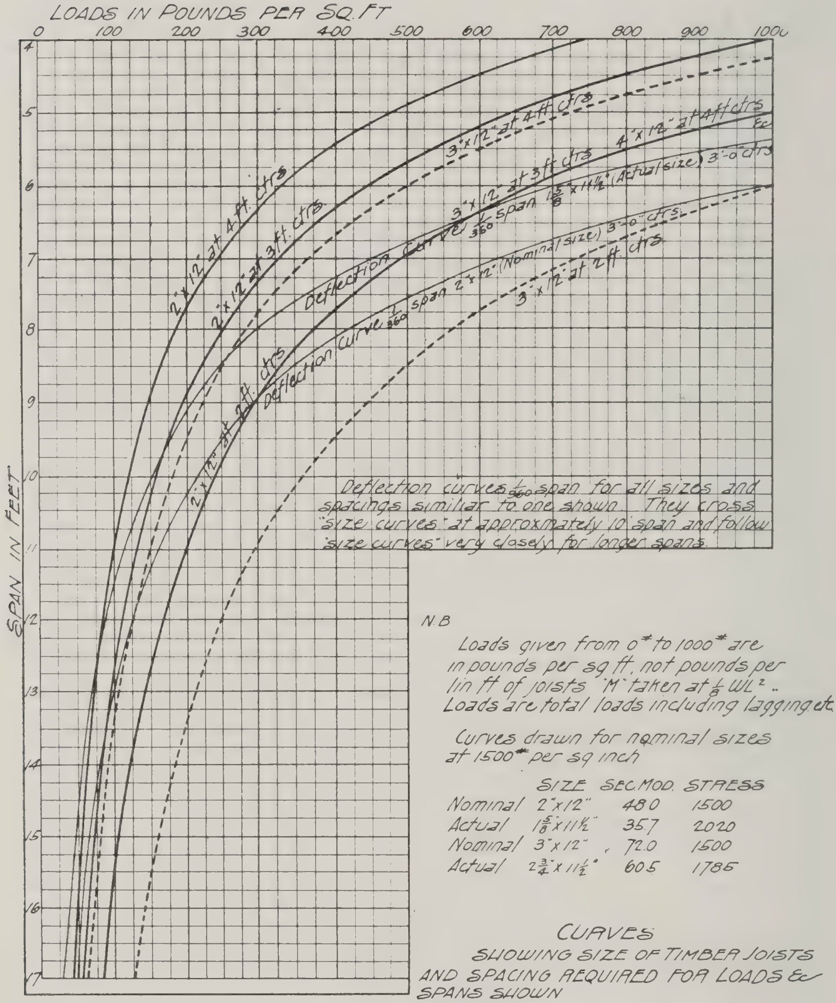

PLATE I.

By Courtesy of the Watson Engineering Co.,
Cleveland, Ohio.

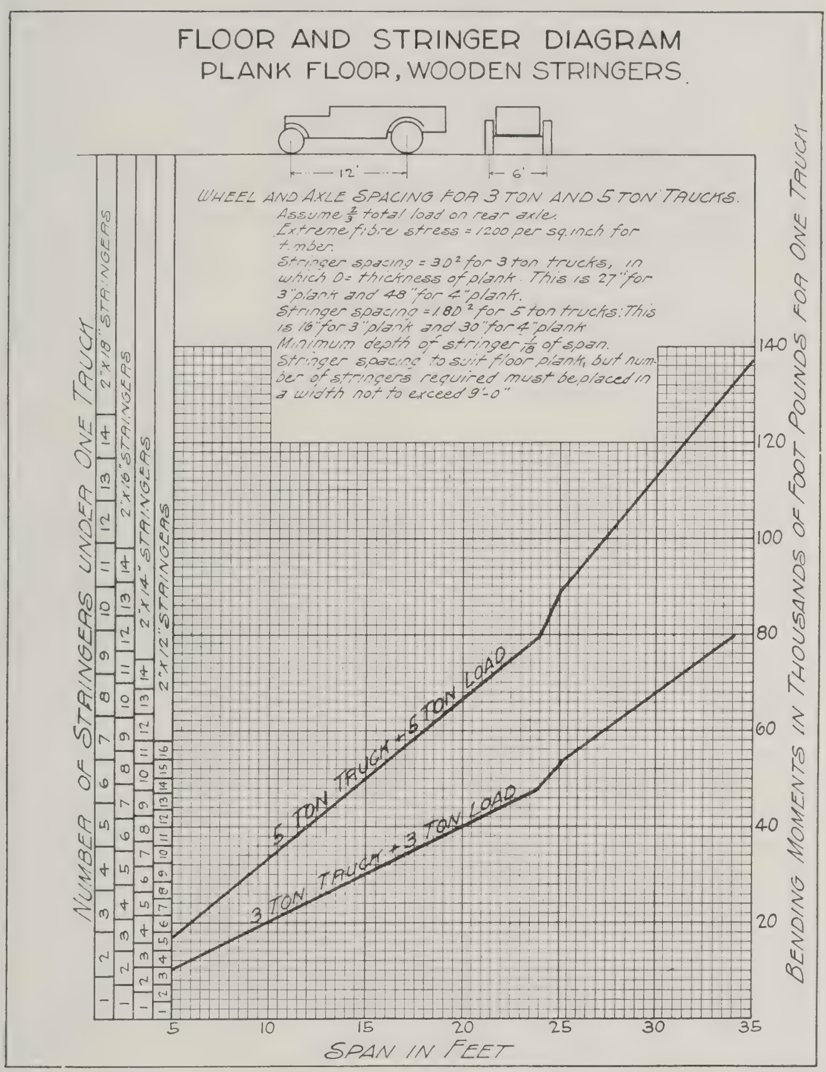

PLATE II.

By Courtesy of the Watson Engineering Co.,
Cleveland, Ohio.

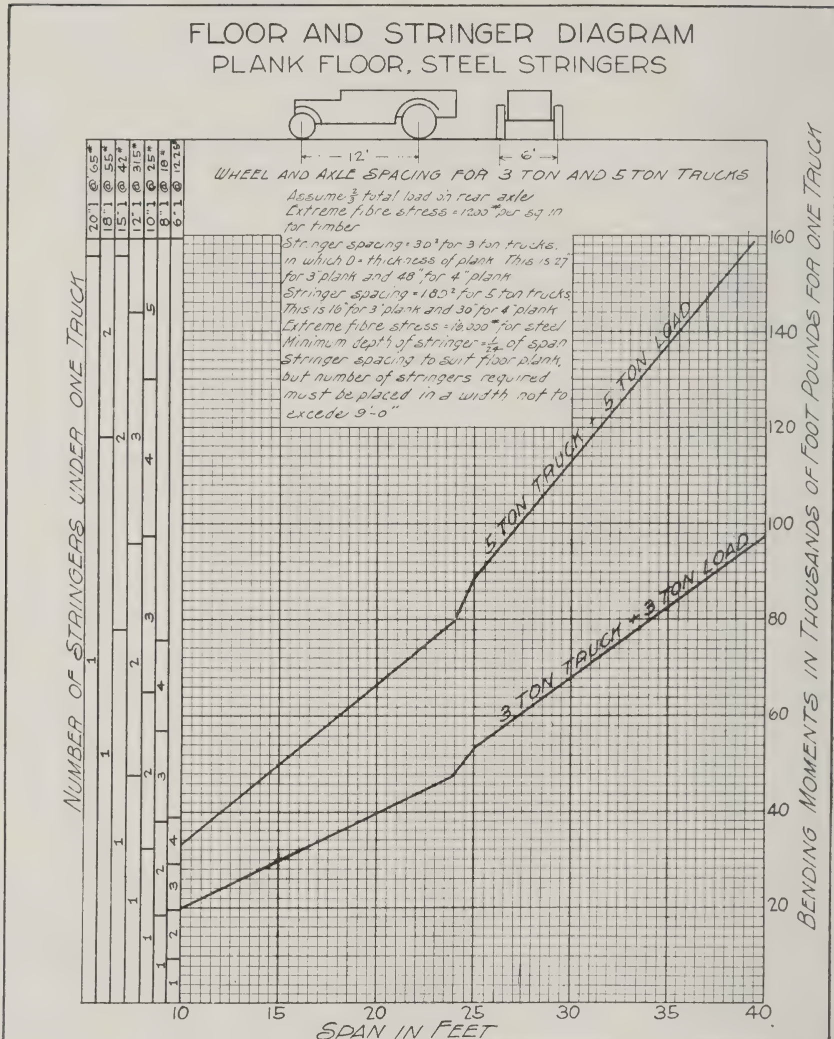

PLATE III.

By Courtesy of the Watson Engineering Co.,
Cleveland, Ohio.

plies. In Figure 22 we have a camouflage screen of vines thrown up to conceal troops passing over a walk on way to front line trenches.

CABLEWAYS.

Another interesting and important means of transporting supplies and ordnance equipment is the use of the cableway and aerial tramways. The former has been used with marked success in the mountainous districts, especially in Italy and Vosges Mountains. In Figure 23 we see one of these cable-railways in operation at Gerardmer in the Vosges Mountains; the line is several miles long and has done much towards solving the shipping of supplies to the advance lines. Various modifications of the tramways are used in the trenches, similar to those used on sewer construction work in civil practice.

SUGGESTIONS ON TRENCH CONSTRUCTION, ETC.

By

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TRENCHES IN FLANDERS.

The majority of the trenches in Flanders are not regular trenches at all. Those of the front line are constructed of sand bag breast-works instead of being cut in the original soil. The communication and support trenches are constructed in the usual manner.

The soil is generally a blue plastic clay; the water level averages from 25 to 30 feet deep; the difficulties of drainage are large, and in underground work it is necessary to keep water pumps constantly going, particularly during the winter season.

TRENCHES FARTHER SOUTH.

In Artois and Picardy and in the Somme region, etc., trenches have been mostly cut in the sandy clay top soil. They vary everywhere in depth and width. The geological formation of this country is a hard chalk subsoil, with water level 200 feet or more in depth, covered with a top soil of sandy clay which varies in depth from 1 or 2 feet to perhaps 30 feet as a maximum.

COMMUNICATION TRENCHES.

Communication trenches vary everywhere, according to soil and other local conditions. In many cases it has not been possible properly to revet these communication trenches. The continual demand for men and material to repair, fire, and support trenches, is so exacting that it is impossible properly to revet all communications. In general, it is advisable to put in duck-boards, and to allow a width which will permit of single files of infantry or other troops passing each other when relieving, carrying up rations, etc.

Many different types of communication trenches are built elbowed, zig-zagged, etc. The important point is to build them

with irregular lines, putting in many bends, so as to confine the effects of shell explosion and decrease the exposure of the men to enfilade fire. Only a general camouflage of this kind can be attempted. Regular lines should always be avoided. Depths will vary according to distance from the front line trenches and general activity of enemy fire. Some communication trenches are started about waist high, gradually deepening to, in many cases, 8 or 10 feet.

Where revetting is absolutely necessary, a uniform system and the same materials should be used where available. Drainage sumps are usually constructed from 10 to 20 feet to the right or left of the communication trench, at intervals of from 20 to 50 yards, and are connected to the main communication trench by deep, narrow trenches, sloped to carry off the water. These sumps should be cleaned out very frequently. Additional sumps can be built in the bottom of communication trenches, say 6 feet deep by 18 inches to 2 feet wide, and 6 to 8 feet long, but these sumps should be avoided where other means of drainage are possible. Care must be exercised in building these trench sumps so that the clay does not slough off too much.

Where the communication trench is dug in chalk, the drainage difficulties will be decreased, but it will be necessary to camouflage the chalk spoil by covering it with clay or other suitable material. Blocking gates are often employed and placed at the junction of communication and support line trenches. (See page 60, "Construction and Equipment of Trenches.") Loopholes for rifle fire should control any occasional long length of trench. Overhead splinter-proof should be provided at intervals, particularly at junctions with fire and support trenches.

FIRE TRENCHES.

Fire trenches are of varying design—Normal, Block, Tenaille, T's and L's, Occasional Forward, etc. There are many arguments, pro and con, for these different types, but the important consideration is to lay out the fire trenches with the same idea of general camouflage, as obtains in other trenches. Fire trenches being the closest to the enemy will require the greatest of care and judgment in their construction. The enemy cannot be kept from getting the range of them before long, but it is a useful thing so to camouflage them that he will at any rate be guessing as to which is the parapet and which the parados. Fire steps should not be made

any wider or longer than necessary. Drainage sumps should be placed under them. Fire steps should be solidly constructed, and all revetment work in these front line trenches should be very substantial and strong. The parapet line should be irregular. Sentries can make their own niches for firing. The use of angle iron posts and expanded metal was found very satisfactory for general revetment. The expanded metal was wired to the posts and the latter were placed at about 2-foot intervals (see notes on Revetment). Where the trenches were very wet, U-frames were placed at from 4 to 6 foot intervals. These U-frames consisted of posts of 2 by 4 inches, bound with angle iron, with a distance piece a foot from the bottom on which the trench duck-boards rested. This gives a foot above the trench bottom for drainage, and in about every other traverse trench sumps are placed similar to those referred to under "Communication Trenches." The parados should be camouflaged in the same general way as the parapet; and when repairs are made care must be exercised to conceal them from observation as much as possible. Dugout entrances should have the bottom sill of first set a foot above the trench duck-board. This can be done by putting in shorter sets for breaking-out sets.

SUPPORT OR SUPERVISION TRENCHES.

It is nearly always possible to put in more careful work on the construction of the support or supervision trenches than on the front line trenches. In general, these trenches are built in the same way. There are, of course, more dugouts here and they are the real headquarters of the Infantry holding the trenches. The selection of these trenches is a matter of great importance, and the obtaining of good observation and the best "fields of fire" for machine gun the first consideration. The safe-guarding of all telephone wires is important, although lines are duplicated and in many cases quadruplicated. These wires keep falling under foot as the sides of trenches fall off and must be replaced in a safe position. The absolute necessity of keeping telephone lines intact is so important that men should be constantly warned to pick up fallen wires and report those broken.

Latrines are usually constructed in trenches leading from communication trenches. A narrow bending trench is dug from the main trench and pits 6 or 8 feet deep excavated. Rough frames are built, often with corrugated iron roofs and sides, and these shelters are carefully camouflaged. Large oil or other cans, per-

forated with holes and placed in the soil, provide simple and effective arrangements for urinals. Chloride of lime and creosol or other disinfectants are used liberally.

DRAINAGE.

Drainage is a big problem in the trenches and on the roads in France, on account of heavy rainfall. Many trenches are constructed in the sunken roads. The drainage of the first-class roads is already provided for by the use of deep ditches running on each side. There are, however, many roads where no attempt at drainage has been made; in fact, the existence of culverts seems to be practically unknown. The use of granite paving blocks—"pave"—is very common, and the other good roads are flint or "metalled roads." These roads are, as described, provided with deep ditches for drainage. The other roads give constant trouble, and drainage sumps are excavated at frequent intervals on either side of the road and these connected up with ditches to carry off the water. Where possible, the water should be drained from our trenches into "No Man's Land" or towards the enemy. A little ingenuity will often enable one to divert considerable drainage to the enemy trenches. U-frames, as described, are used in very wet trenches. Drainage sumps are built everywhere; under fire steps, bottom of dugout entrances, and in all trenches as referred to. The British use hand pumps a good deal in pumping off surplus water. These often get out of order and are easily buried and lost in the mud. There is no reason why, at points some way back of the front lines, gasoline or electrical pumps could not be installed to advantage. The water must be kept down, otherwise the sides of the trenches will continue to slough off, and this will cause constant extra work, discomfort and endless troubles. Water collects in large quantities on the sodden, shell-ploughed surface and sometimes percolates through to the dugouts. The best way to prevent the roof of a dugout in shattered ground from leaking is to fill all shell holes above and gradually develop a slight mound (which will drain) rather than a depression (which will collect water). If, however, the dugout still leaks, then the water should be collected and run into sumps. In chambers this may be accomplished by springing corrugated iron between the girders, allowing a fall to one or other of both walls.

To prevent trench drainage into a dugout, sumps should be cut in the trench at the entrance, not in the galleries at the bottom; though if the water is already in, soak pits may be made down

below to let it drain. This idea would appear to be obvious, but it is often overlooked.

SHELTERS.

The enemy build large numbers of either thick steel plate or heavily reinforced concrete shelters and strong points in the trench itself, in addition to their elaborate system of underground galleries. The Allies, however, content themselves mainly with constructing as many deep mined dugouts as are necessary, afterwards connecting these up underground, when possible.

There are many types of shell-proof shelters, description of which you will find in the army texts. One important point in their construction is to limit the thickness of dirt to 9 inches on top of the top bursting course. Where an H. E. shell hits a shelter of this description and penetrates through several feet of solid earth, the earth naturally serves as additional tamping and causes this result in a much more intensified explosion. A 9-inch top of earth will be sufficient to catch most of the splinters, but on account of its shallowness cannot serve as tamping.

Splinter-proof shelters are very easily constructed of sheets of corrugated iron and sand bags, or of other material available In all shelters, including mined dugouts, it is most important to have the timber of the structure well braced to withstand shock of explosion. Always play safe, if it is possible to get the material.

As a bursting course, concrete seems to be superior to broken brick or flints, but it should be carried well over the sides of any shelter.

REVETMENT.

The general trouble in revetting trenches is that the Infantry, and sometimes the Engineers, will insist upon building vertical, or nearly vertical, walls or sandbags. The result is that in the course of a few days, and always after heavy rains, the sides will slough off and considerable more work is necessary to rebuild than if they had built the revetment with the proper batter. The head and stretcher method of placing sandbags is the best, being careful to tamp all bags solidly into place and fill in all cavities behind with clay or chalk. A very practical method of construction is to build up this revetment vertical for about 3 or 4 feet in height, and then to build the remainder at a slope of even 25 to 30 degrees from the vertical, placing the sandbags here at right angles to

the new slope. Afterwards, if possible, use expanded metal and posts, brushwood, wire netting, timber or other available material to reinforce revetment; but this sandbag method described will usually hold for some time, even if it cannot be reinforced, especially when bags filled with chalk are used.

In hard chalk, revetment is only necessary where sides of trenches have been destroyed by fire. Use stout wire for anchorage, and do not place posts too close to the edge of trench.

CAMOUFLAGE.

Camouflage is not the business of a special engineer company, but the work of every man who is wise enough to wish to avoid observation. Portable camouflage is provided, usually in the shape of wire nets, chicken wire, or something of that sort. This wire is threaded with raffia, long grass, brushwood, or suitably painted sandbags or other material. In the trenches, all regular outlines of every description must be avoided. Warm colors look dark and cold colors look light. Roads, railroads, trenches, etc., show up very plainly. It is wise to avoid unnatural shapes which throw shadows. Where canvas is painted, it should be done with irregular lines; should be darker than the surrounding ground and with edges ragged. This subject is covered in some pamphlets and the study of these is recommended.

Pay particular attention to the camouflage of dugout entrances; emplacements of all descriptions, mine shaft heads, junction of communication and other trenches, and all spoil brought to the surface.

With regard to the latter, the spoil is usually placed at night in shell holes, abandoned trenches, behind hedges, in sunken roads, and other places where concealment from horizontal observation is possible. Bear in mind at all times the aeroplane observation as well as the horizontal observation. The camouflage of regimental camps, etc., is extremely important and must be carefully studied. Study carefully with a strong magnifying glass the aeroplane photographs covering your sector of the front. You will notice from week to week little changes in the enemy's lines, which, with careful study, will furnish you with important and useful information. In general, camouflage should seek to retain or copy pre-existing conditions to avoid changes which will be revealed by later photographs.

TRANSPORT.

Every unit has its own transport. All tools, machinery, building material, rations, ammunitions and supplies, etc., are brought up after dark in the trucks and wagons of the regimental transport. In most cases they are driven as far as the advanced material billet or rendezvous. These advance billets are commonly situated about three-fourths of a mile to a mile from the firing line trenches. Here everything is taken on to the forward trenches by carrying parties detailed for the work. It is also common practice for the Infantry working parties assisting Engineer Units to be met at this point by guides from the Engineers, and the latter, after the carrying and working parties have loaded themselves with the material and tools to go up, march up the trenches to the different places where the work is progressing. Reliable guides should be detailed; one usually leading, and the other following the working party, to see that they arrive without unnecessary delay and with the correct timber, etc. Infantry working parties have a happy faculty of losing themselves very easily. All officers, drivers, etc., must study very carefully the maps of their area provided for them, and must be able to find their way around confidently by night and day. During the winters, the British found it necessary to establish "road control," or a system of detailing the various types of transports to travel by special routes, in order to allow opportunity for properly repairing the more commonly travelled and direct roads.

EMPLACEMENTS FOR STRONG POINTS.

These include emplacements for trench mortars, machine guns, snipers posts, artillery observation posts, etc. It is necessary and advisable to change the position or emplacement of the heavier machine guns from time to time; in consequence, their emplacements are mainly earth platforms, and they are usually located by M. G. officers and built by their own crews. There are, however, some machine guns which occupy secret emplacements. These guns are only used in cases of emergency, and the construction of these positions is more elaborate than the others. Trench mortar emplacements are also quite simple, usually pits excavated in the soil, from 8 to 10 feet square and 6 to 8 feet deep. Mined dugouts are always located very close to machine gun and trench mortar positions.

Snipers' posts should be constructed with the utmost care and

only used by the Snipers themselves. As a rule, it is advisable to leave their construction to the Infantry, although Engineers build them when requested according to their design and requirements.

Specially constructed observation posts for Artillery and Infantry are not common; advantage being taken of various positions suitable for observation already existing in most trenches.

DISPOSAL OF SPOIL.

All spoil handled in sandbags, and brought out during the day is either used in the revetment or repair of existing trenches, or else stored in what are termed "daylight dumps"; at night these sandbags, filled with clay or chalk, are moved from the "daylight dump" and spread around on the top of trenches in shell holes and abandoned trenches, etc. Where men are working at night in "No Man's Land," or any point within range of enemy machine gun or rifle fire, it is wise to warn them as to their conduct when the enemy's star "Very" lights go up. The "Very" light is a white rocket, usually bursting high in the air and breaking into a number of white stars which light up the ground all around within a radius of, perhaps, 100 yards in every direction. When these lights burst close, every man should either stand still or drop flat. In the event of the light going beyond or behind a party, it naturally throws their figure into relief, and in this event they should drop at once. Under ordinary circumstances, it is quite sufficient if they stand or keep still. This is important. Naturally, an officer will try to arrange his men on top, so that they are exposed as little as possible. It is always necessary to see that the infantry working parties dispose of all dirt properly, and in addition camouflage all spoil. This requires constant supervision on the part of the officer. Do not allow engineers or infantry working parties to throw the sandbags from the trench upon the top of the parapet or parados. Make them place all bags by getting on top themselves, naturally at night, and either empty the contents or place bags in shell holes, etc., or build up the trench by a proper trench revetment system. At every opportunity, they will, unless watched, be anxious to get rid of them and throw them up anyhow, and this will surely result first, in your work being noticed by the enemy and consequently "strafed" very shortly, and secondly, in your trenches being built up to a height of 10 or more feet, with great danger of the whole trench

falling in and burying sentries when mines are exploded in the vicinity. Do not fill bags more than three-quarters full. Split up your working party according to the number of jobs you have on hand, and detail, if possible, one of your own N. C. O's. in charge of each group. An infantry officer always accompanies a working party, and you will find him of assistance, but you are in charge of and responsible for the work, as well as the safety of your men. See that your own parties and the infantry working parties come into the trenches in small sections and that proper care is exercised in taking all cover available. Warn them not to show their rifles, or any of the timber, or tools, over the parapet whilst they are carrying them up. They should make no noise in coming in, and should only talk in low tones as necessity demands when working on top close to the enemy. The latter may be occupying a forward listening post near them and open fire on the whole party. No smoking can be allowed during work on top. Keep in touch with the officers of infantry holding the line and inform them of the location of your night working parties.

Warn your men about lingering in trenches which are found to be exposed to enfilade fire from enemy, and at points such as the conjunction of communication trenches, with firing and support lines. These are favorite targets for the enemy. "Stand To," or "Stand To Arms" with the infantry always takes place one hour before daylight and one hour before dusk.

MINED DUGOUT CONSTRUCTION.

The following methods are the result of considerable practical experience. They are not the only ones, but selected as being the most widely adaptable; many modifications, suited to varying conditions, are possible.

1. *Standardization.* It is recognized that a considerable saving of timber, labor and time can be effected by the standardization of dugouts. The following standards are suggested:

A. Bunks to be $6'6'' \times 2'$.

B. Minimum inside width of chambers, with rows of bunks on each side, $7'$.

C. Minimum height of galleries or chambers, in the clear, $6'$.

D. Minimum width of entrance, $2'9''$.

E. Entrance frames, $5' \times 2'9''$ (for use in entrances in which the frames are set at right angles to the dip).

F. Use of standard case for gallery ($3''$ or $4''$ casing, $6' \times 4'$ inside dimensions).

2. *Cover.* Cover depends largely on the class of ground. Tunnel dugouts must be sufficiently deep below the surface to compensate for a lack of bursting course. When building dugouts in the winter season and where the surface has been liberally pitted with shell holes it will be wise to go deeper and adopt precautions to insure the drainage being properly taken care of at the outset. The following may be considered minimum cover under such circumstances:

For chalk, 25′.
For clay, sand or earth, 30′.

In chalk a considerable saving in timber can often be effected by going 10 feet or 12 feet deeper for a start.

3. *Location.* Location of these dugouts will be determined by consultation with the Infantry, Artillery, or other units who propose to occupy them, should usually be constructed in groups, each dugout of a group being joined to the other.

4. *Nature of Timber Joints.* Some objection is raised to the use of the mortise-and-tenon joint, and solid-butt joints with spreaders have been suggested as an alternative. General experience, however, has shown that the use of the mortise-and-tenon joint, as standardized in German dugout construction, allowing for wooden wedges at the joints, is the better practice. German underground work is almost invariably close timbered. Cases of 4-inch oak or hardwood, using from 9 by 4 inch to 12 by 4 inch timber, is generally employed. Galleries, 6 by 4 feet (inside dimensions), are found everywhere in their lines, and the sets are usually braced by wedges at the joints, one being driven in the bottom sill of one set, and the next in the top sill of the succeeding, and so on.

5. *Earth Pillars.* For pillars of solid earth between chambers nothing less than 10 feet should be considered, even in the most solid chalk; in clay still larger pillars should be left. Timbering naturally varies with different designs. Chalk weathers very rapidly in dugout chambers, and should be protected in some way by lagging, expanded metal, corrugated iron, etc. The use of wire netting packed behind with straw is useful, but has the disadvantage of harboring vermin.

6. *Entrances.* Nearly all dugouts have two or more entrances, and these are usually built in from the bottom of the trench at an angle of 45 degrees. They should be well concealed and have not

less than 5 feet of head cover, with bursting course, if possible. A good plan is to strut the trench well opposite the entrance. The entrance to a Dressing Station dugout should have an incline of 30 degrees.

Stepping down in the trench is recommended in starting entrances if additional sumps are provided to take care of drainage.

Entrances should be close timbered, even in chalk, for a distance, of at least 15 feet and preferably the entire slope. Many designs for entrances are given in the texts. If the entrance is started directly from the bottom of the trench, with little head cover available, double breaking-out sets should be put in. These breaking-out sets will usually be short in order to obtain adequate cover. After the initial sets have been placed it is the best plan to place the sets at right angles to the dip. A combined bomb trap and sump can be placed at the bottom of entrance, if necessary, and partially timbered over. The sill of the first entrance set should be at least 12 inches above the duckboard of the trench. The necessity of bracing timber very carefully is emphasized and of using spreaders and stringers to reinforce. Nothing less than 3-inch timbers should be used for entrances. It must be remembered that the shock of a bursting H. E. shell is almost vertically downwards, and that sets are liable to collapse in the direction of the dip unless securely supported. For this reason, entrances should be close timbered to a depth of absolute safety, so that the sets below will prevent those affected above by the shock from collapsing. Do not attempt to dig a hole for four or five sets to be timbered later; it endangers the lives of those working, and if the face or sides begin to "run," involves an immense amount of labor and leaves an entrance weak and unsatisfactory, which will give constant trouble later. As a guide, when excavating for entrances timbered at right angles to the dip a template in the shape of a 45-degree triangle with about 2-foot sides and a plumb-bob should be provided. The use of 2- by 5/8-inch iron straps, spiked about 6 or 8 inches from the top and bottom of the sides is recommended. Failing this, 1 by 4 inch boarding can be used. Steps or ladders for this type of entrance made of 1½ to 2 inch lumber are put in afterwards. These steps are made up usually in 6-foot sections and nailed in place. The average progress per shift of 8 hours should be about 4 or 5 frames set, and the class of ground, whether clay, soil or chalk, should make little difference. When changing direction from 45 degrees entrance with

average sets (5 by 2 feet 9 inches), set at right angles to the dip, to a level gallery of 6-foot head room, one special set is required together with some specially cut lagging boards. This construction is similar to that of the breaking-out sets.

7. *Galleries.* Spilling. (Supporting the roof at the head of excavation.) In loose, heavy ground, this is the only method to adopt, for comparatively shallow work down to 25 or 30 feet. It is always the best method even though it takes slightly longer.

Advantages:

(*a*) Roof is kept as solid as possible and bears evenly on the timber.

(*b*) Men working are in no danger from falls of roof.

(*c*) In shattered ground it prevents the face "running," which if once started means considerable trouble, and results in reducing the cover over dugout.

The waling board is of 3- by 3-inch timber, and rests on distance pieces, placed on top of the cap piece of the ordinary frame. The distance pieces must be large enough to allow the spilling boards (*i. e.*, overhead lagging) to be driven forward by hammering between the whaling board and the top sill.

The spilling boards are maintained at the original angle by using a spare cap as a distance piece, bearing on lagging or spilling boards of the set behind.

Sometimes, in very heavy ground, the spilling boards bend with the weight before they can be driven home; in this case, intermediate temporary sets are used. The forward one supports the end of spilling boards, while the back one serves as a distance piece to maintain the angle of drive. The boards are driven from underneath the cap.

This method, of course, necessitates the excavation of the ground between sets in two distinct operations, first to place the intermediate set, then to place the permanent set.

In any case, as soon as the weight begins to come on the back, lagging boards will rest on the waling board of the forward set. and this in turn on the lagging, so that the whole becomes absolutely tight.

Spilling boards should be at least 1 foot longer than the span between sets.

When spilling in chalk it is often necessary to pick out the ground ahead of the spilling boards in order to facilitate driving; in this case only pick out enough to allow one board to be driven at a time.

8. *Chambers.* In almost all ground an 8-foot span is too great to stand without intermediate props, but there is no need to place the intermediate prop in the center of the girder. When it is intended to bunk the chamber later, the intermediate props may be set leaving a space of 2 feet from the wall prop, alternately first on one side and then on the other, thus giving a maximum span of girder of approximately 5 feet 6 inches, which is sufficiently strong for almost any ground.

It is always advisable to avoid notching props (the process only weakens them).

To prevent the props from pushing inwards when side pressure begins to come on, it is advisable to shrink on clips or brackets, but old horseshoes, or, in fact, all kinds of scraps have been used. Brackets and clips are commonly made by units and differ considerably in strength and pattern.

Spacing of girders. The general rules are:

In clay, sand or soil, 1′ 6″ centers;
In chalk, 2′ 0″ centers.

After the girders are set, it is necessary to strut them to prevent them from rolling over or pushing out sideways. The method usually employed is to wedge struts of 4 by 3 inch timber between one girder and the next. Four such struts are used, one at either end, and two spaced 3 feet apart from the intervening length of girder. Care should be taken to wedge these in extremely tight.

When chambering in clay, sand, or soil, it is necessary to provide foot blocks about 12 by 12 by 3 inch for each pit prop. In chalk this is not necessary. Props should be cut 3 inches longer and let into the floor 3 inches. In case of clay, sand and soil, the foot block is left in below this again, but the weight of the roof will generally press it down the extra 3 inches.

Spilling. Little need be added to remarks on spilling in connection with galleries, but this safe method of working cannot be insisted on too strongly. When driving chambers the intermediate sets are replaced by intermediate girders supported by pit props, or by using ordinary cap pieces of gallery frames supported by pit props, just to hold up the spilling boards prior to setting the forward girder.

9. *General.* In figuring on carrying parties, you can estimate one man to carry 100 bags along 100 feet of gallery per 8-hour

shift, and one man can carry 100 bags up 10 feet of entrance per 8-hour shift. These figures will apply to gallery and chamber work. In almost all trenches taken over, it will be found that there are a number of dugouts already built, and in addition to building more it will be necessary to inspect and probably repair a number of these old ones. Make the design of dugouts as practical as possible, having in mind the materials which can be used in your area. Always figure three to four times the strength necessary to support merely the load, due to the thickness of roof entrances. Where necessary, a hole can be drilled through the roof of the dugout to provide additional ventilation, and may be used for a periscope. It is also desirable to construct an alternative or emergency exit behind the parados to a surprise position for machine gun (see pages 55-56, "Construction and Equipment of Trenches"). Each dugout should be connected by speaking tube to a sentry post. The latter should be given as much protection as possible. Two picks and 2 shovels should always be kept in each dugout for emergency. Frames of standard dimensions will doubtless be supplied from engineer trains. Timber is very seldom framed on the spot.

Wire Entanglements. This subject is taken up in detail in the military texts and pamphlets. The Infantry make up and place many of the entanglements. As a general thing, the wire entanglements in front of the fire trenches are not as thick and wide as they are between the front and support line. Wire entanglements for "No Man's Land" are made up back of the line, or in the trench, carried out and placed in position at night, most of the work being done beforehand in the trenches. Wooden posts should not be used in "No Man's Land." It is not a healthy practice. Angle-iron knife-rest entanglements are very practical for use here, and the cork-screw, pointed, or other iron posts are also useful. When out laying wire at night, do not fail to notify the infantry officers occupying the trenches as to the time and place you propose working, otherwise you are likely to be taken for a hostile working party and have your crew blotted out.

RETREAT OF ENEMY.

Enemy's Destruction. In a planned retreat, the enemy will do all the mischief they possibly can and destroy everything which may shelter or be of possible advantage to the pursuing forces, in addition to impeding pursuit with many obstacles.

In the retreat of Arras, the following conditions were encountered: The enemy had leveled all houses, walls, and buildings of any description, seldom leaving any wall of a height more than 3 feet. Nearly all the houses and buildings in this area are built of hard chalk blocks with brick foundations. They blew in all the cellars and destroyed entrances to all shelters, dugouts, and chalk caverns. Most of the wells were destroyed; others they attempted unsuccessfully to poison with chemicals. All trees were cut down to within a foot or 18 inches of the ground, this work having evidently been done with gasoline saws. Trees, many of them of large diameter, were felled across the road to impede traffic, also across streams and rivers. All bridges were destroyed. The rivers are not wide in this district. At practically every crossroad and at quarter-mile intervals on the roads, mine craters were blown, varying in size from 60 to 70 feet in diameter to 200 feet or more, the depth of these craters varying from 20 to 50 feet. Many dugouts, galleries, and shelters were destroyed by fire.

Delayed and Contact Mines and Bomb Traps. Numerous devices were employed for mines and bomb traps. Railroads were undermined with large charges of high explosives, and the first trains going over after the evacuation were destroyed. Contact land mines were placed at crossroads, which would be fired by heavy vehicles crossing them. A large number of dugouts were mined. The charge, as a rule, was placed half way down the dugout entrance on the right or left side. It was usually observed that the timber or casing was slightly disturbed, but to detect these changes it required a sharp eye. The charge was connected by leads to one of the dugout entrance steps, so that it was fired as a man walked down to the dugout. These charges were tamped with sand bags. Many delay-action mines were left in the large dugouts or headquarters; several brigade headquarters went up after they had been occupied by the British for ten or more days. Numerous bomb traps were found. The German "hair brush" bomb would be tied by means of its fuse cord to a loop of wire; soldiers would catch their feet in these loops and so fire the bomb. The "egg" bomb was fastened in many other instances underneath the trench duckboards; stepping on these would explode them. Many souvenirs, helmets, etc., would be hung on nails in dugouts, and these would be attached to bombs which would explode on making an attempt to remove them.

General. Much ammunition, high explosives, timber of all de-

scriptions, and many other stores were left behind the enemy in districts where the retreat had evidently been more hurried. They had destroyed, or partially destroyed, nearly all of their reinforced concrete shelters and steel plate observation posts, etc.

The bulk of the above demolitions were carried out by the use of German high explosives, Westfalia and Perdit, etc. Many caches of the latter explosive were found, some in large quantities. These high explosives used were similar to ammonal and were easily detonated by us with primers of dry gun cotton and blasting caps. As many engineer and other units as could be spared were immediately put on to road repair and road construction work. Where the roads ran through the old trenches, it was found necessary to take the timber from the nearest German dugouts and corduroy them. Plenty of brick was used where no other material was readily available and was of undoubted temporary value. Later it was replaced with road metal.

Conclusion. It would appear to be wise to go very carefully in following up the enemy on any retreat, especially a planned one. Evidence of planned retreats in trench warfare is not difficult to obtain. For a week or more before the retreat, many fires are observed in enemy lines and villages; numerous small and large explosives are heard everywhere, and much valuable information secured by the Air Service. Numerous delay and contact mines and bomb traps of all descriptions can be looked for in his lines everywhere, and considerable caution must be exercised in withdrawing them. It is essential that road building material be available in large quantities close up to the lines in order to insure rapid pursuit, and enable the artillery to be brought up as fast as possible. An efficient "road control" should be immediately established and one-way and double-way traffic routes arranged. In addition to the road and other work, engineers are required to investigate and withdraw all mines laid and pick up all bomb-traps, etc. Later, after a preliminary reconnaissance has been made, the salvage of immense amounts of dugout timber, steel plate, and other material and stores left behind by the enemy is effected by the engineers and used later to good advantage.

Traffic must be kept moving as fast as possible, and when tie-ups occur by trucks being ditched or broken down, every effort must be made to repair quickly or remove them from road somehow. Enemy planes or artillery immediately take advantage of these situations to make things unpleasant. Some useful road material

is often secured by blowing up carefully some of the enemy's concrete posts.

BOMBING.

The enemy does not stop to inquire as he comes over your parapet as to whether you are an infantryman or an engineer, so it is necessary that every engineer on "first line" work be well able to take care of himself, and in this regard the use of hand bombs or grenades is very effective. Training in bombing and in the construction and use of our bombs as well as of those of the French British, and the enemy will be given you later. Study particularly the manner of throwing the commoner varieties of enemy bombs. At present it is only necessary to say that the calmness and confidence developed from the use of bombs will stand you in good stead in emergencies. The universal bomb (Mills) used by the British has been found very successful and almost "fool-proof," and our grenades will have similar safety features. A little care at the outset when training in the use of bombs will save casualties; many accidental casualties occur in bombing practice on account of either "jumpiness" or recklessness. It is advisable also for engineers if possible to learn something of the construction and use of machine guns. In modern trench warfare the engineer is often called upon to defend himself and he must be familiar with all weapons and practiced in their use. Needless to say, he should be a first-class rifleman. The British Engineer Units always carry their rifles with them into the trenches. Observe the location of bomb boxes or stores in the advanced trenches. In making their rounds of inspection in these trenches at night, officers are recommended to carry a couple of bombs in their pockets.

GAS ALARMS.

The surface gases encountered are chlorine, phosgene and bromine. These gases are all heavier than air and are released under high pressure from steel cylinders in the enemy trenches. The gases roll over in big clouds at velocities varying from 5 to 15 miles per hour according to the wind. In an average nine mile wind the gas would reach trenches 100 yards distant in 20 seconds.

The use of gas appears to be growing less, as it is essential that the wind be exactly in the right direction and the wind velocity

also favorable. If the wind happens to shift at the last minute, naturally all of your own men may be gassed.

Preliminary drill and training in the use of gas helmets is absolutely necessary, and men are passed through these gas drills until they can put on their helmets in, at the most, 5 seconds. At the base camps, every officer and man reporting will doubtless have to go through a gas chamber to test his confidence in the helmets. Once one has this confidence in the use of a gas helmet, very little fear is felt as to gas attacks. Gas helmets are issued and carried by all troops operating within 3 or 4 miles of the front lines and must be carried by every one whether in the trenches or in camps behind the line. It is usual for each man to have a second helmet in case of loss or injury to the first.

Gas alarm signals are arranged by having at frequent intervals in the trenches and at all villages within 3 or 4 miles of the line notice boards with notices "Gas Alert On" or "Gas Alert Off" on them. When the "Gas Alert On" signal is shown, all troops in the front trenches carry their gas helmets at the alert position on the breast so as to be easily available for immediate use. When the signal "Gas Alert Off" appears, the gas helmet is carried in the usual way, hung over the left shoulder.

In addition to these notices, there are signal horns, much like powerful automobile horns, and gongs composed of shell cases with a striker attached, by means of which the alarm is immediately sounded. If a gas attack should occur on your sector, the only thing is to do is to take it quietly. Pull your gas helmet over your head as fast as you can, and proceed to "stand by" to man the parapet in case of infantry attacks following the gas. You will, of course, see that all of your men put on their gas helmets at once. Warn every one not to hurry over anything and not to exercise more than is necessary, in fact, to do nothing which will quicken the heart's action

Officers will order gas drills frequently and make careful inspection of the gas helmets carried by their men. The enemy sends over gas in a variety of ways; one of the commonest methods is to send it over in gas shells. The German 5.9-inch shell, holding about 7 litres of a gas producing liquid seems to be the best medium for transmission. These gas shells do not burst with the usual loud report, but fall and burst like a dropped melon, releasing the poisonous gas.

The lachrymatory or "tear" shells are used constantly, but

this gas only affects the eyes, and does not do material harm. Sponge goggles are provided to cope with it. It is mainly designed to use against gunners.

The asphyxiating and suffocating gases are far more severe in their action. Sprayers are provided in the trenches for spraying the blankets of gas-proof dugouts and shelters, and for neutralizating effects of gas in dugouts.

When the British put over gas attacks, it is their practice to leave only the gas men and the Lewis gunners in their front lines. Engineers are warned by the Brigade Staff to withdraw their men at each of these attempts.

TRENCH ORGANIZATION[1]

From

"The Making of a Modern Army and Its Operations in the Field"

By

Rene Radiguet
General de Division, Army of France

. . . .

General Remarks. When her dream of a short war which was to realize all her aims of conquest was dissipated, Germany resorted to a policy of occupation in the hope of either maintaining her hold upon the territory she had seized, or else of eventually using it as an asset in negotiations for peace. At the end of 1914 she occupied nearly the whole area of seven French Departments, three or four of which are among the richest agricultural and industrial districts of France.

To attain her ends, Germany intrenched her armies on the nearest front that she had time to occupy, one of several defensive lines which she had selected long before. Her spies, in time of peace, had furnished her with accurate knowledge of all the important positions.

Thus, when the German armies of the first line were beaten on the Marne, and fell back in disorder, they found, at a distance of three or four days' march, beyond Soissons, on the frontier of Lorraine, an unbroken line of intrenchments already organized by the second-line troops while they were operating their enforced retreat. . . .

The French pursuing armies had not, in September, 1914, the material means of assaulting the enemy's intrenchments. They had just fought a series of battles which had considerably lessened their effective forces. Their regiments had to be officered anew. They had no alternative but to intrench themselves, on positions as little disadvantageous as possible, in front of the enemy. Thus all along a line extending from the North Sea, at Nieuport, to the

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[1] G. P. Putnam's Sons, New York, 1918. Reprinted through the courtesy of the author and publishers.

frontier of Switzerland, began the formidable conflict which is still raging.

The distance between the two hostile fronts varies from 30 to 40 metres to 1,200 or 1,500 metres at most.

After big attacks, prepared by long bombardments, the first lines cease to exist, and very often both of the hostile fronts are merged into one another. The most advanced small outposts have no other shelter than that of shell-craters, and it is by means of grenades thrown from one crater to another, and with whatever earthworks can be improvised with the tools on hand, that attempts to rectify the fronts are made.

Both parties, most of the time, have three successive lines of organized defence, and sometimes more.

It is to be noted, however, that while the Germans have adhered to the three-line principle in the sectors where they believe themselves but slightly threatened, on the fronts where they are heavily pressed by the Allied Armies, they have organized, as their advanced lines weakened or were forced, a series of very strong positions, one behind the other. . . .

It is interesting to remark that the multiplication of large-calibre artillery has caused changes to be made by both belligerents in the construction of shelters and intrenchments.

During the winter of 1914-1915, no serious bombardments took place before April. Both sides organized themselves on their positions, excavating shallow shelters which were braced with wooden beams and roofed with two or three layers of logs, over which earth was more or less thickly packed. Such shelters resisted well enough 150 mm. shells.

But, in 1917, during the operations in Artois and Champagne, the adoption of larger calibres, and the use of torpedoes fired by trench machines, compelled the belligerents to bury themselves more deeply in the ground, wherever the soil permitted, and to build more solid shelters. When water interfered with deep excavations, the shelters were covered in with very strong T-shaped iron railway ties, or with several layers of steel rails; but these proved insufficient, and the Germans were the first to construct those bombproofs of reinforced concrete which the British for the first time encountered on the Somme. The concrete blocks are very large and the steel reinforcing bars extremely strong. Such works certainly impede and delay the operations of the enemy, especially when they are extensively employed, but events have proved that,

given time, they can always be destroyed by gun-fire. The French have constructed similar works only at points of capital importance. They prefer the old wooden shelters, well reinforced with earth.

At all the inhabited places in their lines, and at points of natural strength, the Germans have organized independent centers of resistance. They have transformed whole villages into fortresses. . . .

In every one of those places a surprising number of concrete constructions and superimposed subterranean galleries were discovered. In them the enemy had collected reserve troops, food, and munitions. Such shelters, no doubt, afforded the Germans great protection, and in order to destroy them it was necessary to have recourse to more and more powerful methods.

An officer of the 81st Regiment of Infantry which captured Mort-Homme writes as follows: " . . . and on the hill where the 81st Regiment is encamped, what an accumulation of defensive agencies! Wire, tunnels, trenches, observatories, shelters of every description, machine-gun posts, light cannon, nothing is lacking. To these ordinary means of defence, other extraordinary ones had been added, consisting of three immense and very deep subterranean systems (82 steps led down to one and the length of another exceeded one kilometre) provided with ventilators, Decauville narrow-gauge railways, electricity, posts of command and relief, rooms for the men, and stores for food, arms, munitions, and material. All these extraordinary fortifications could not resist the impetuous assault of our troops, which had been preceded by a six-day bombardment so intense that the entire first line was enveloped in a thick cloud of smoke about two hundred metres high, and the ground shook all the time."

In fact, no absolutely impregnable shelter has yet been devised, and the story of fortification is but a repetition of the story of defensive naval armament. The thicker the plates of the dreadnoughts, the more powerful the guns are made, and the guns have the last word.

Moreover, it has been by no means demonstrated that the German intrenchments, which have cost enormous sums, and an amount of human labor that the Allies would have been unable to furnish, have to any extent reduced the enemy's losses. On the contrary, it appears that the temporary protection afforded by such works is more than offset by the great losses in men and material which is the result of their final destruction. . . .

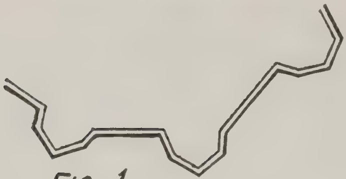


FIG. 1

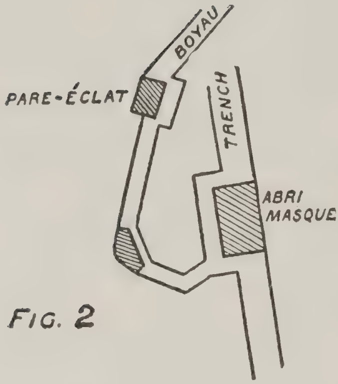


FIG. 2

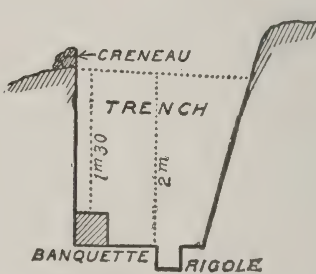


FIG. 3

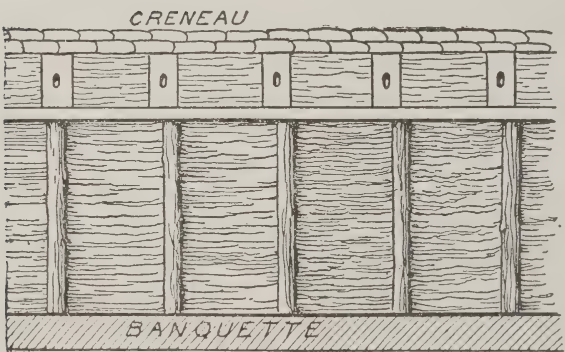


FIG. 4

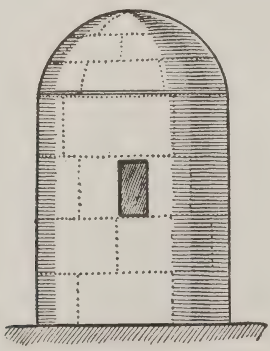


FIG. 5

General Plan of an Intrenchment System. The description we give hereafter of the organization of the lines is, of course, like the preceding diagram, purely explanatory and illustrative. . . .

The plotting-out of the trenches is of very great importance. They must be made in such a manner that they will not be exposed to an enfilading fire of the enemy's guns, and will be strong enough to oppose the greatest resistance to attack.

Too long and too straight lines are generally avoided. The usual custom is to reproduce the ground plan of a bastion, with alternating salients and re-entrants, a disposition which permits flank firing across the front of the trench (Fig. 1).

The re-entrants are frequently additionally fortified so as to render them insurmountable to assault, so that the defenders need occupy the salients only. Advanced trenches exposed to intense bombardment can thus be defended with a smaller number of men.

The inside of the trenches is provided at short intervals with *pare-éclats,* or shell-screens, consisting of buttresses of earth supported by *clayonnages,* or wattle-work, which are intended to limit as much as possible the radius of action of a bursting shell to a single section of trench (Fig. 2).

The trenches are of different dimensions; nevertheless, when time is not limited for their construction, Fig. 3 can be considered as representing the most generally adopted type. The earth thrown up in front, either loose or filled into sand-bags, forms the parapet.

As the action of the weather, especially rain, tends to cave in the sides of the trenches, they have to be upheld with wooden props, or with wire nets, supported at three or four metre intervals by wooden or iron posts.

In the very damp regions small drains (*rigoles*) and cesspools have to be dug to carry off the water, and the trenches themselves must be provided with open "boardwalk" flooring. When not pressed by time and scarcity of material, especially in winter, all possible means should be adopted to prevent the men from standing too long in water. Dampness, more than cold, is responsible for frostbitten limbs.

In the parapets of trenches that are expected to last some time, loopholes are made by inserting pieces of sheet-steel with openings to allow the passage of a gun barrel. Each opening closes with a small door which remains shut except when the loophole is in use (Fig. 4).

When neither time nor material is lacking, the machine-gun shelters (Fig. 5) in the trenches are installed within steel cupolas, which are either stationary or revolving. The mechanism of the latter is, however, complicated, and too delicate for use in the first lines. These cupolas are also much used for observation posts, and, as we shall see later, they are kept as much as possible concealed from the sight of the enemy by camouflage.

The first line comprises three positions or trenches. That nearest to the enemy is the advanced trench, and at a short distance behind it are the support trenches. Only a few men are now posted as sentries in the advanced trenches. In front of these trenches, "listening" or "watch" posts are hidden in the ground. Between these posts and the advanced trenches barbed wire entanglements are stretched, in number and width proportionate to the dangers threatening the position.

In the support trenches are the dugouts sheltering the men against the fire of the artillery. Many communication trenches or *boyaux* connect them with the advanced trenches, facilitating the rapid occupation of the latter in case of need. In the advanced trenches are built shelters for the machine-guns. Rifle-fire is directed through loopholes protected by the steel plates above mentioned (Fig. 4) which are bullet-proof at fifty yards.

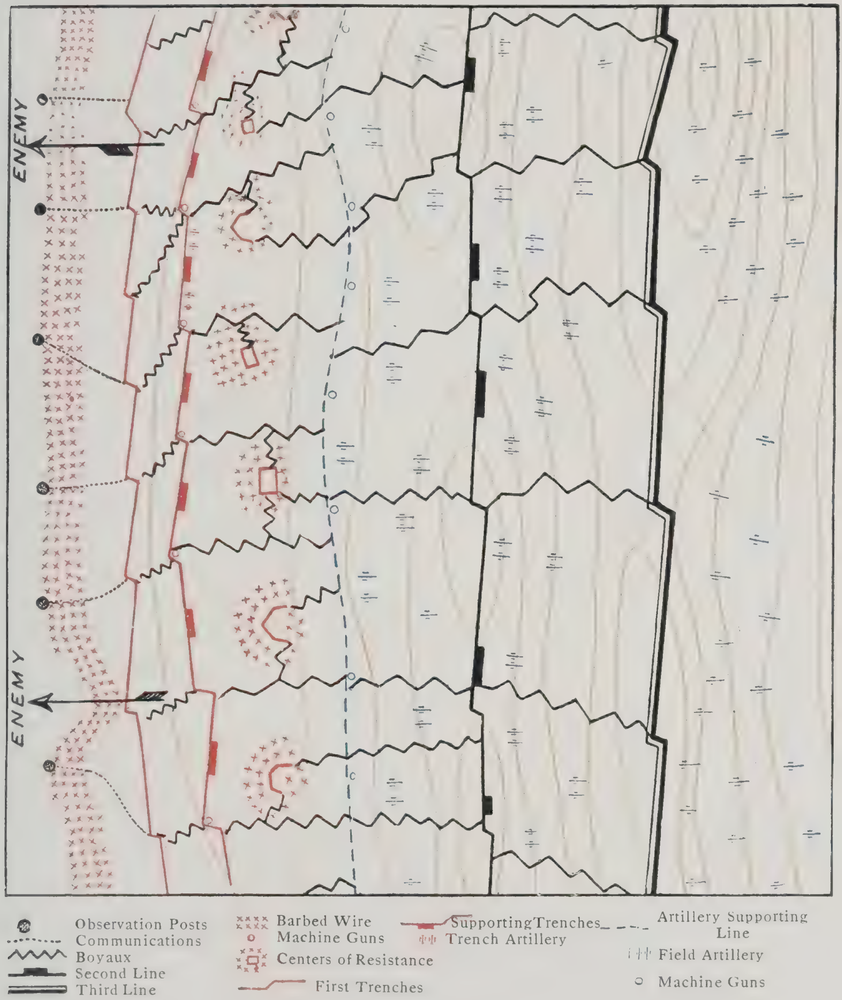
At some distance to the rear of the support trenches and overlooking them, the first-line system is reinforced by a line of "centers of resistance," which is punctuated with block-houses protected by thick wire entanglements. Well sheltered machine-guns, a certain number of which sweep the communication-ways leading to the front, compose their main armament. This block-house line is connected by many communication-ways with the trenches in front of it.

These centers of resistance are intended to check the advance of the enemy, when they succeed in breaking into the three anterior lines, and to give the reserves time for counter-attacking.

Between the block houses and the second-line system a fortified line is frequently organized which is called the "protecting line of the artillery." This is intended to repel the advance of the enemy infantry, if they gain possession of the first-line system, before they reach the field batteries, or to retard it long enough to allow the batteries to fall back. This line is held by the troops of the sector which do not belong to the fighting contingent.

The distance from the first-line system of trenches to the

DIAGRAM OF CAMPAIGN INTRENCHMENTS



second-line system varies according to the configuration of the ground. These second lines should, when possible, overlook the first lines, so as to hold them under their fire. The same rules prevail in the location of the third lines. In the sectors which seem to particularly interest the enemy, very strong "check positions" are prepared in the rear.

The troops occupying the second and third lines should be protected against bombardment as much as possible. It is therefore in these trenches or very near them that shelters capable of withstanding heavy gun-fire should be constructed.

We say "in or near" advisedly, for it is important to hide the shelters as much as possible from the enemy, and, to effect this, it is no inconvenience to build them a little in the rear of the trench-lines, if the desired result can thus be obtained. Often it will be necessary to do this merely for the purpose of getting more favorable ground on which to erect the shelter.

The main point to emphasize is that these shelters should be connected by means of communication-ways permitting quick passage from the shelters to the trench lines.

In all three lines, when the ground is suitable, observation posts are located, but however well they may be concealed, the enemy is not long in discovering them, and in the first line it is generally with the aid of different kinds of periscopes that the observations are made.

Communication Lines. All the trenches are connected by communication trenches or *boyaux,* which conceal from the enemy the movements of troops. These are mere ditches about two yards deep, the earth from which is thrown out to the left and right, or on one side only. They follow a zigzag line so as not to be exposed to enfilading fire, or, when straight, are protected at intervals by earth screens (*pare-éclats*).

The depth or breadth of these "ditches" depends on the use to be made of them. For instance, those intended for carrying out the wounded must be deep and wide.

To preclude obstruction during attack, and to provide free and quick passage for reserves rushing up from the rear, communication trenches should be very numerous. Some should be designated for forward and some for rearward movement. Each one should bear a name or a number and at its extremities arrows should indicate the direction of the circulation. Thus confusion will be avoided.

TRENCHES OF ATTACK. When the opposing lines are sufficiently far from one another, it is impossible to launch an attack without having brought the infantry within striking distance.

For this purpose a sufficient number of *boyaux* are dug in the direction of the enemy, starting from the advanced trenches, passing under the wire entanglements, and connecting together with a cross-trench when at the required distance. This is the "trench of attack" and at the proper time, steps are made in it to facilitate the egress of the troops at the moment of assault.

This work is done at night, and preferably, when possible, by troops which are not to take part in the attack. The men proceed to this work under cover and patrol guard.

ARTILLERY. The artillery, according to its size, is placed between the lines or behind them. Field batteries are pushed forward up to the "artillery protecting line" and placed in position to shell, at any time, certain designated portions of the enemy's front. They are either buried in the ground or sheltered under casemates, when the latter can be concealed from the enemy.

The trench guns are, generally, on account of their small range, placed in the first-line support trenches.

The heavy artillery, farthest back of all, is drawn up in echelons according to its size and the part assigned to each part of it.

WIRE ENTANGLEMENTS. The width of the wire entanglements varies considerably. Well strung wire prevents any attack, and none can be attempted until the entanglements are destroyed. In front of their new lines on the Aisne, where the Germans are simply holding the ground, and have given up all notion of advance, they have stretched eight or nine successive rows of wire, each row being fifty metres wide.

Wherever defence only is contemplated, the protection of wire is essential, but it will be well to bear in mind that too many entanglements may prove inconvenient at the time of an attack. We have seen that in such cases; the difficulty is solved by digging communication trenches under the wires.

MINES AND COUNTER-MINES. Since both parties dug themselves in, much use has been made of mines and counter-mines, especially in 1915 and a part of 1916.

The aim of the mine is to throw the enemy into sudden consternation and disorder, while destroying an advanced trench, or work. The French considered the mine as a weapon with which it would be possible to remedy at certain points the defects of their line.

They caused heavy losses to both parties, but are not so much used now for the very good reason that, where the fronts have undergone no change since 1914, the soil has been so greatly disturbed that it would be absolutely impossible to make the necessary excavations. We shall simply recall that in June, 1917, the British, prior to their attack on Messines, set off twenty mines, each containing twenty-three thousand kilograms of explosive, and as the Germans were not aware of their construction, the effect of the explosions was terrible, producing huge craters, seventy metres deep and several hundred metres in circumference.

Mines are dug by hand or electric drills. The latter have the disadvantage of making too much noise. Greatly improved systems of "listening posts" permit the enemy's operations to be detected and opposed, and in all cases, excepting at Messines, where the British bored their galleries at more than fifty metres under ground, mine digging was carried on under great difficulties.

The best means to neutralize the danger of a mine whose construction is discovered, is to reach it as quickly as possible by excavating a "counter-mine," and blow it up before the enemy has a chance to set it off. The success of such a counter-mine is termed a *camouflet* inflicted on the enemy.

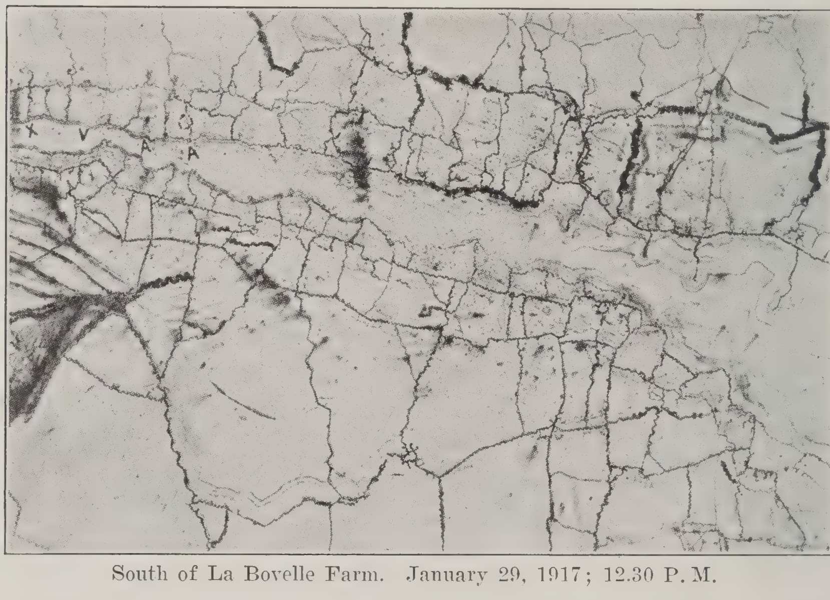
In our opinion, mines and counter-mines will play a less and less important part in the present war, but it will nevertheless be necessary for our armies to be provided with the means of operating them whenever the Command may deem them advisable.

SPECIAL RAILWAY TROOPS.—TRANSPORTATION BY ROADS. Since the beginning of the war, France has been lacking in special technical corps, especially for the railways. Her ante-bellum system was insufficient to cope with the rapid development of the military operations, and the reorganization rendered necessary by trench warfare along an extensive front.

A large proportion of the railroad employees was at first mobilized to assist and reinforce the railway troops. Then, after a few months, a large number of these men had to be sent back to their former civilian duties, in order to assure the economical life of the country.

While the transport of troops alone requires a daily extension of our road and railway systems, and constant attention to repair work in the fighting zones, the industrial efforts of the nation to equip and arm the millions of combatants also necessitates an enormous railroad activity. As the lack of workmen prevents

La Bovelle. December 29, 1916; 3 P.M.



South of La Bovelle Farm. January 29, 1917; 12.30 P.M.

locomotives and carriages from being repaired, and the supply of rolling stock shipped from America is not sufficient, it is as much as the French can do to keep their railroad tracks in good condition.

It should be noted that owing to the intense and forced use of her interior lines to which we have already referred, the railways of Germany are in still worse condition than those of France. For want of oil and grease a large portion of their rolling stock cannot be used.

To make up the deficiency in technical troops, France has had to have recourse to her "territorial units," composed of men unfit for the front and generally more than forty-five years old, who, exhausted by three years of war, are unable to do much work.

This short résumé of the conditions prevailing on the rear of the French front will enable the Americans to comprehend the necessity for organizing on a very extensive scale a special railroad transportation corps. Without interfering with traffic on the principal roads of the United States, it should be possible to create railway regiments officered by civil engineers, with separate units for track construction, operation of trains, and repair of rolling stock.

The engineer regiments should likewise be enabled to build rapidly field barracks of all kinds in the zones devastated and abandoned by the Germans.

They should, moreover, be entrusted with the erection of hospital and ambulance buildings, and their removal and reconstruction whenever new ground is wrested from the enemy.

Transportation by Road. Except in the immediate vicinity of the lines, where horses are still used by the regiments for transportation between the camps and cantonments and the bases of supply, all the conveyance of men and material, which is not made by rail, is done by motor cars, in daily increasing numbers.

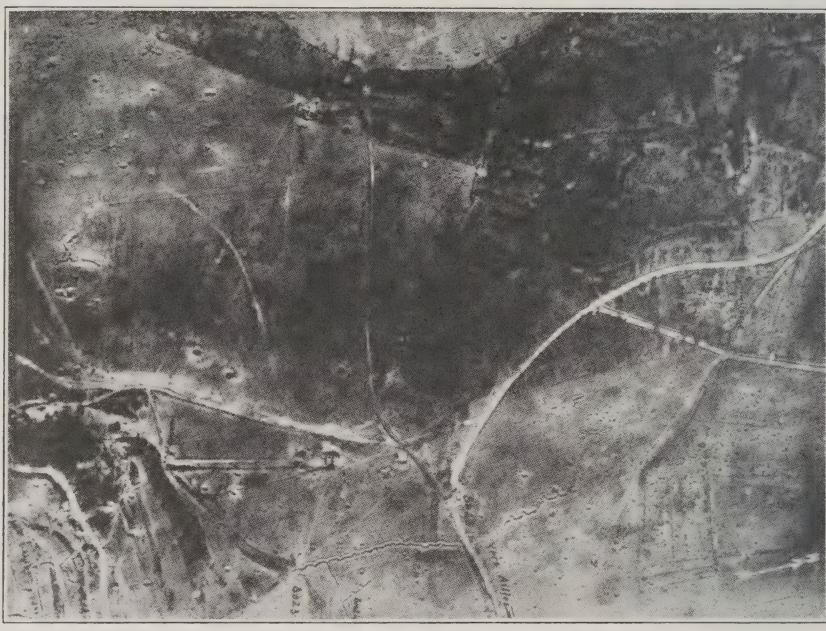
Not only have the railways from the rear to the front been increased in number, but also the communication lines running parallel with the front. Their capacity, however, being inadequate for moving large units quickly from one part of the front to another, motor cars should be on hand in number sufficient for the rapid transportation of an entire army corps.

There should be a permanent service of motor cars between the front lines and the rear, to assume the task of taking fresh troops to the line and exhausted troops to the camping grounds. They can be used also, and with great efficiency, when circumstances at the front require the prompt advance of reserves from the various bases.

We shall see later how motor cars are used for the supply of food or ammunition. Many more cars are needed for the hospitals, ambulances, and the carrying of the wounded.

The consumption of gasoline, notwithstanding the suppression of the abuses which were for a long time prevalent on the Anglo-French Front, remains considerable. France is supplied with it exclusively by the United States and Mexico.

General Remarks on Transportation. The question of supplies of all sorts will be one of the difficulties connected with the



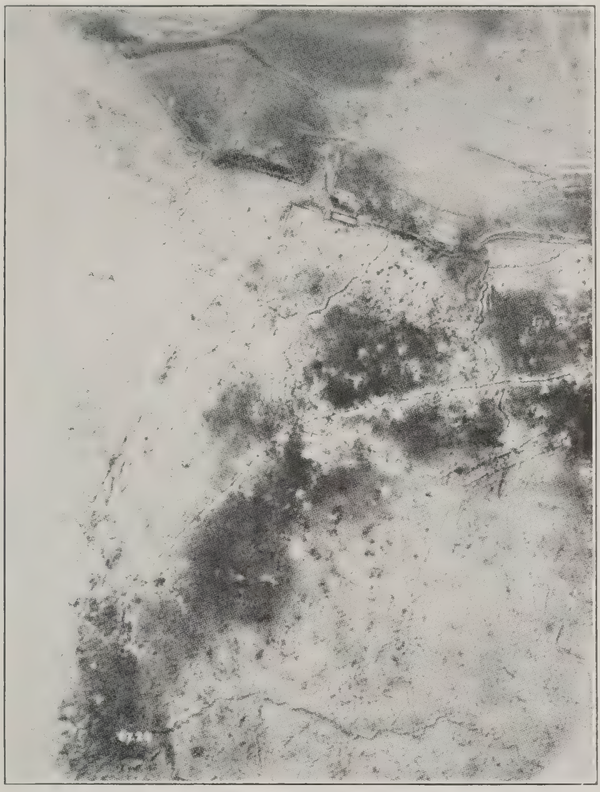
West of Ailles. April 24, 1917; 10 A. M.

organization of the American Armies on French soil. The United States will not merely have to convey troops from one continent to the other, but also to ship all that is necessary for the subsistence of her armies, their upkeep, their armament, their artillery, etc., just as if they were expected to land in a desert country where the barest necessities of life would be lacking.

The American Government and the General-in-Chief have from the start been aware of the difficulties awaiting them, and, immediately after the landing of the first troops, very important works were begun for the improvement of the French ports of

landing and for the duplication of French railroads, wherever needed. This work is being actively carried out under the direction of American engineers.

CAMOUFLAGE. Everything pertaining to the equipment and



La Bovelle. May 5, 1917; 10.30 A. M.

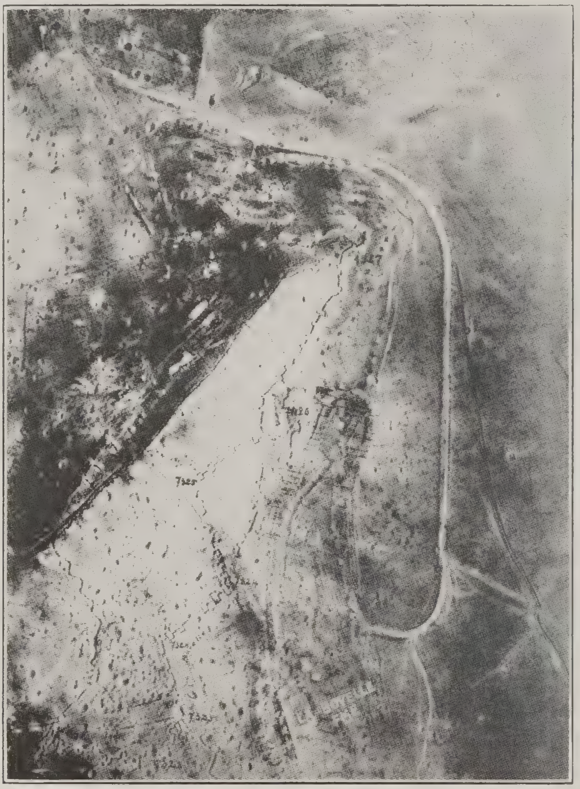
employment of troops must be hidden, so far as possible, from the sight of enemy aviators, and the various devices resorted to for this purpose are termed "Camouflage" (disguise).

Artillery, transportation parks, ammunition dumps, camps, roads of communication, etc., are masked in many ways, on the general principle of causing the object to be concealed to blend with the tint of the soil or the foliage, or to melt into the landscape and avoid the eye. Coverings of brushwood or straw represent the simpler, and framework supporting artificial greenery or painted canvas, the more ambitious forms of camouflage. Ob-

jects irregularly blotched with paint of different colors are practically invisible at a certain distance—a device borrowed from the "protective coloring" of the animal kingdom.

Batteries of dummy guns are often used in this, as in former wars, to deceive the enemy.

It is highly important to have good points of observation



North of La Bovelle. April 24, 1917; 10 A. M.

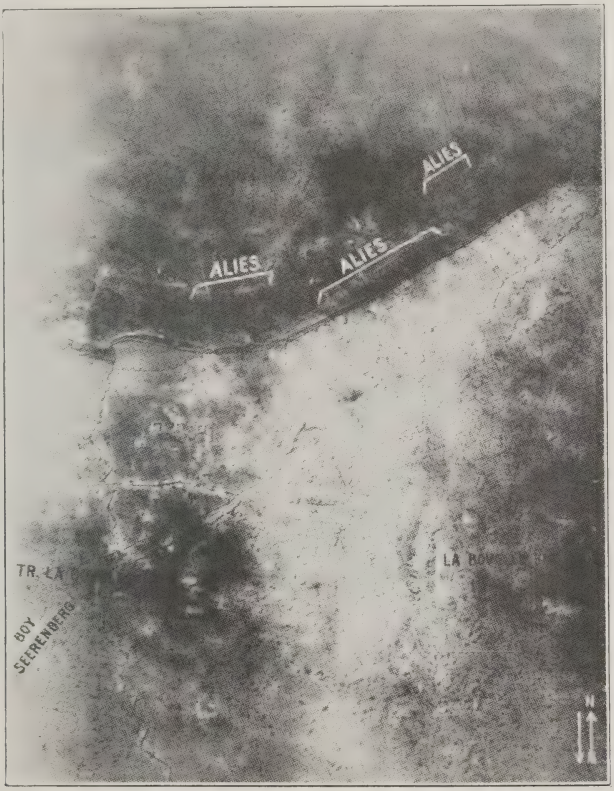
within the first lines, whence the enemy's defences may be searched with powerful field-glasses. To meet this need, artificial trees, rocks, etc., have been provided when nature failed to supply them.

The camouflage of the French army has been entrusted to a special corps of professional artists, which has proved a most useful unit, since it is necessary that the work done should deceive not only the human eye, but the sensitive plate of the camera. . . .

AVIATION

. . . .

The services rendered by the reconnoitering airplanes are of the greatest importance. Their observations supply the Command with accurate information concerning everything that is taking place within the enemy's lines; the condition of his front; the movements



La Bovelle. May 5, 1917; 10.30 A. M.

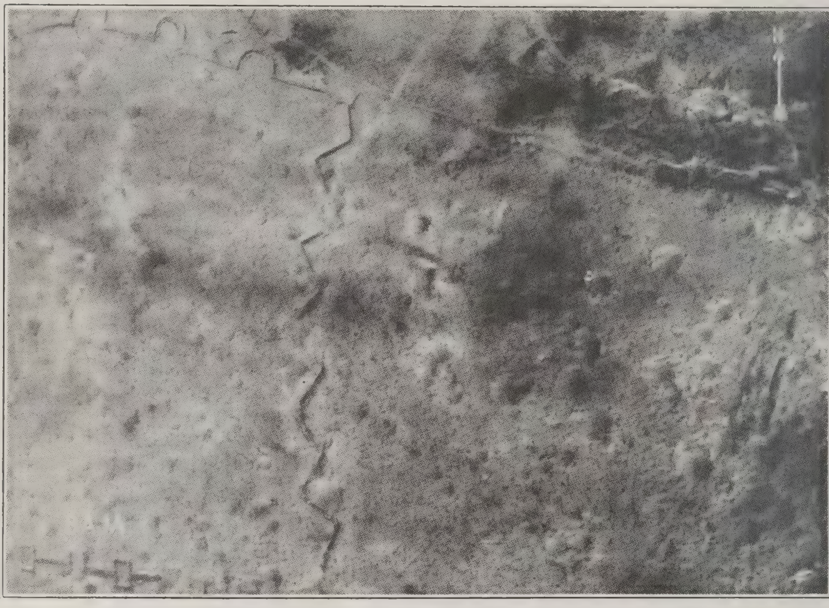
of troops in his rear; thus enabling the Chief to foresee his intentions and foil his plans.

In addition to reports of what they observe during their flights, the pilots obtain aërial photographs. This very important adjunct of our modern armies has been considerably improved.

Photos taken at an altitude of 2,500 and 3,000 metres (8,000 to 10,000 feet) reproduce so accurately the configuration of the land with every object on it, that trained officers are able to observe in

them the smallest changes that have been made. With this object in view they compare together several photos of the same place taken at different dates.

We include in our volume some aërial photographs of the German lines in the Aisne sector taken at the end of December, 1916, in January, 1917, and in April and May, 1917. The first show merely the enemy's works before the French bombardment. The pictures taken in April of the same ground give an excellent idea of the progressive effect of the French artillery, and the last photographs,



View taken about 10 A. M. during the attack of May 5, 1917.

taken during the attacks of the 5th and 6th of May, show the final result of the tremendous shell-fire. In order to compare the changes effected from time to time, it is necessary to use a magnifying-glass, and to note successively each observation on a large-scale map called a "directing map." This minute, painstaking method alone will enable the Staff to form an idea of the effect of the artillery, and the progressive demolition of the works and trenches of the enemy. Later on we will see that the observations reported by the reconnoitering aviation influence in a great measure the dispositions taken for attack.

The British attach, and rightly so, such importance to a strictly accurate record of the effects of their fire, that they are not satisfied with the usual charts, but construct for their principal staffs large-scale relief-maps including both their own and the German lines, works, and batteries, as revealed to them by photographs taken from airplanes and captive balloons. Officers of the General Staff are specially entrusted with the duty of recording on this relief-map all damage and destruction as fast as it is reported. When the order of attack is given, the British chiefs, knowing as far as it is possible what works they will find destroyed, and what points will offer a

View taken about 10 A. M. during the attack of May 5, 1917.

more or less stubborn resistance, make their dispositions accordingly.

No attack is possible if the Command is not daily informed by the photographic section. Even after a continuous bombardment it is more prudent to defer an attack if during the preceding days the weather has been so bad as to prevent the use of the aërial cameras. . . .

Before concluding, we should like to be granted the privilege of expressing our personal opinion concerning the methods calculated to hasten the instruction of the new armies of the United States.

Everyone agrees on the necessity of proceeding rapidly and effectively.

The defection of Russia on the Eastern Front and the recent very serious reverses of the Italians, of which the Germans have not failed to take prompt advantage, have rendered more difficult the efforts of the Allied Armies on the Western Front.

The instruction of the American units can be terminated in France, first in camps and afterwards in quiet sectors, until the American High Command considers that the moment has come to throw its forces into the thick of the fight.

Notwithstanding the immense resources of the United States, the difficulties of transportation will doubtless be such as to force the military authorities to hold a certain number of divisions in the instruction camps in America.

The instruction of these troops ought, we think, to be as thorough as possible.

The Allied countries have delegated to the United States distinguished officers who have participated in the war and who know all its difficulties. We should wish them to proceed, if only on a short front, with an exact reproduction of the shell-torn fields over which the American troops are destined to manœuvre in Europe. The small units that could be successively and frequently trained on these prepared fields would thereby have less time to spend in the instruction camps in France and could more promptly be sent to the Front.

In the vast territories of the United States, ground adapted to this purpose would not be difficult to find, and the plan would afford opportunity to give the last divisions to embark complete instruction in all matters of detail, and a perfect knowledge of all the component elements of an army, from those of a company to those of a division.

Let us insist on the fact that, in this war, the art of rapid excavation and intrenchment is one of the chief things to be learnt by the troops, as special formation cannot be detailed for this work, and every soldier has to carry an intrenching tool and must know how to use it.

It will therefore be necessary for the units to practice intrenchment on a large scale, and finally to perfect their instruction by exercise over shell-torn ground similar to that of the Front.

We would suggest, in order to familiarize the troops with the actual mode of destroying defensive works, practice with such

obsolete artillery as is not fitted for use at the Front. It is of paramount importance also to accustom the men as rapidly as possible to the sight and sound of gun-fire. We would suggest that the final exercises of assault be accompanied by curtain fires made, to avoid all risks of accident, at about three hundred metres in advance of the first lines.

We can add that the mode of instruction we advocate here would be as beneficial to the Chiefs as to the men. Thus only will they fully realize beforehand the difficulties they will meet when facing the one factor which it is impossible to include in any course of training—the Enemy; an enemy that, to the end, will be skilled and formidable.

THOMAS HOWARD RUGER

By

Lieut. J. B. Brown
Engineer Reserve Corps

Thomas Howard Ruger was born in Lima, Livingston County, New York, on April 2, 1833. He was the son of the Rev. Thomas Jefferson Ruger, an Episcopal clergyman in charge of the parish at Lima.

About 1846 the family moved to Janesville, Rock County, Wis., where young Ruger attended the public schools. On the 1st of July, 1850, he was appointed cadet in the United States Military Academy.

As a student at West Point, Ruger was noted for his retiring disposition and for an unusual diligence in the performance of his duties. He was particularly good in mathematics.

He was graduated third in his class and was commissioned Brevet Second Lieutenant, Corps of Engineers, July 1st, 1854, and ordered to report to Capt. P. G. T. Beauregard, at New Orleans, for duty. He was sent to complete certain construction work at Fort St. Phillip, Louisiana. This was Ruger's only assignment before the Civil War, as he resigned his commission the 1st of April, 1855, and returned to Janesville, Wis., where he studied for the bar and afterwards practiced law until the outbreak of the war in 1861.

On the 29th of June, 1861, Ruger was commissioned Lieutenant Colonel of the 3rd Wisconsin Infantry. Shortly thereafter the regimental commander, Col. Chas. S. Hamilton, was promoted, leaving the command of the regiment to Ruger, who received his commission as Colonel on September 1st, 1861.

The 3rd Wisconsin Infantry was assigned to duty in and about Washington, and in September, 1861, Colonel Ruger was sent to arrest disloyal members of the Maryland Legislature, a difficult piece of work, but one handled with such thoroughness and dispatch that he was commended by his higher commanders, and by the President. In December of 1861, he was assigned as Provost

Marshal of Frederick and vicinity, and under his administration there was no more trouble with the Maryland Legislature.

In the operations of 1861 and 1862, the 3rd Wisconsin Infantry participated with great credit both to its commander and to the men of the regiment, especially at Winchester, May 25th, 1862, and during the advance to Little Washington, Va., in July, 1862. Among the earlier battles of the War in which the 3rd Wisconsin participated were Cedar Mountain, August 9th, 1862, and Antietam, Sept. 17th, 1862. In his report on the latter battle Gen. George H. Gordon, commanding Williams Division of the Twelfth Corps, says "Colonel Ruger is entitled to the highest praise for his skill and gallantry in battle." Colonel Ruger was slightly wounded in this engagement. Shortly thereafter he was promoted to the grade of Brigadier General of Volunteers; he did not, however, receive his commission until the 29th day of November, 1862, being at that time just under 30 years of age. General Ruger commanded his brigade in the Rappahannock Campaign, and at the battle of Chancellorsville, May 2nd, 3rd and 4th, 1863.

In the Battle of Gettysburg, July 1st, 2nd and 3rd, 1863, the Twelfth Corps was commanded by General Slocum. During his temporary absence, General Williams, commander of the 1st Division, assumed command of the Corps, the command of the 1st Division falling to General Ruger. Generals Williams and Ruger were especially commended for their work in this great battle.

In the middle of August, 1863, General Ruger resumed command of his brigade, which had been increased to 11 regiments, and conducted it to New York to suppress the draft riots.

When this work was completed, General Ruger returned to his Corps, which, with the Eleventh Corps, was transferred to the Middle West. Early in 1864, the Eleventh and Twelfth Corps were consolidated to form the new Twentieth Army Corps, in which General Ruger remained as a brigade commander. Among the battles in which the Twentieth Corps participated were, Resaca, Ga., May 14-15, 1864; New Hope Church, May 25th; Kolps Farm, June 22nd; Peach Tree Creek, July 20th; Siege of Atlanta, July 22nd to September 2nd, and campaigns around Atlanta, September 2nd to November 8th, 1864.

At request of General Schofield, General Ruger was transferred to the command of the Second Division of the Twenty-third Army Corps, which was assigned by General Sherman to the forces

of General Thomas. The Twenty-third Corps was engaged in the entire campaign against Hood, which ended with the practical annihilation of the Confederate Army of the west at the Battle of Nashville, December 15-16, 1864.

For a time the Federal troops were hard pressed and forced to retreat to Nashville, fighting delayed engagements during their retirement. The most noteworthy of these engagements was the Battle of Franklin, Tennessee, November 30th, 1864, where General Ruger particularly distingushed himself by rallying his men and charging the enemy who had penetrated the Federal works. For good conduct at this time he was brevetted a Major General of Volunteers November 30th, 1864.

After the defeat of General Hood, the Twenty-third Corps was transferred east and took part in the operations of Sherman's Army in North Carolina.

With the surrender of Gen. Jos. E. Johnston, April 26th, 1865, General Ruger was assigned to the command of the District and Department of North Carolina, which command he held until September 1st, 1866, when he was mustered out of the volunteer service but reappointed in the Regular Army with rank of Colonel, of date July 28th, 1866. He was assigned to the command of the 33rd Infantry.

On March 2nd he was breveted Brigadier General in the Regular Army for gallant and meritorious work at the Battle of Gettysburg.

After being relieved of his command in North Carolina, General Ruger held various commands in the South during the trying reconstruction period, where he performed his delicate duties with tact, firmness and justice. He was Commander of the Department of the South from March 5th to May 31st, 1869.

From September 1st, 1871, to September 1st, 1876, General Ruger was Superintendent of the Military Academy at West Point. During this time Brigadier General Emory Upton was Commandant of Cadets. It would be difficult to find two men better fitted for that important duty. General Ruger in appearance and manner impressed the Cadets deeply with the dignity of his high office. Yet, his kindliness was equally in evidence, and the Cadets felt that in an appeal to him they would be sure to receive a courteous and sympathetic hearing. On relief from duty at West Point, he was again commander of the Department of the South until July, 1878. He was commissioned Brigadier General, March 19, 1886, and assigned

to the command of the Military Division of the Pacific and the Department of California. His next command was the Department of Missouri. He received his commission as Major General February 8th, 1895, and was retired April 2nd, 1897.

From January, 1901, until the time of his death, General Ruger was President of the Military Service Institution. He was a member of the Military Order of Foreign Wars and of the Loyal Legion of the United States, besides being an honorary member of many other civil and military societies.

General Ruger was married in 1857 to Miss Helen L. Moore, of Beloit, Wis.

After retirement General Ruger travelled in Europe for two years. Returning, he resided with his family at Stamford, Conn., until his death which occurred June 3rd, 1907.

He was a man of whom West Point may well be proud. Beloved by his class, and appreciated by his instructors, his four-year course developed his natural characteristics in a manner made evident by his long and honorable service.

Book Reviews.

Elements of Military Sketching and Map Reading. *By* Capt. John B. Barnes, Fifth U. S. Infantry; 3rd edition, revised. 6th thousand. New York, D. Van Nostrand Company, 1917.

vi, 100 pp., 39 figs., incl. illus., maps, sketches, forms, and diagrs. 16 cm.

The book is of a convenient size to carry in the pocket. It treats of sketching in general, of road sketching, position sketching, landscape sketching, map reading, etc.; it explains the meaning and representation of conventional signs, abbreviations, contours, map distances, vertical intervals, etc.; it gives instructions in the use of the sketching implements, and of the cavalry sketching case for plotting hasty surveys, the use of a watch to determine the meridian where you have no compass, and other simple methods of determining directions and distances with all the accuracy that may be required for a hasty reconnaissance. It is illustrated by 39 good line-cuts, which make it both useful and attractive; it condenses much valuable practical information into a very small compass, and is admirably adapted to the object for which it was designed.

Military and Naval Recognition Book. A handbook on the organization, insignia of ranks, and customs of the service of the World's important armies and navies. By Lieut. J. W. Bunkley, U. S. Navy. 51 full-page plates, 18 in colors. New York, D. Van Nostrand Co., 1917.

ix, 224 pp., 51 plates (18 cols.). 18 cm.

A Handbook on the Organization, Insignia of Rank, and Customs of the Service of the World's Important Armies and Navies.

"The following pages were prepared, not only for those in the Military and Naval Service, but also for the laymen who, since the beginning of the war, have shown a keen interest in the uniforms, insignia, and customs of our fighting force. The information was all obtained from official sources and every effort has been put forth to make it as correct and as complete as possible. Special stress has been laid on the insignia of rank, which has been shown in the most minutest detail. . . .

"The chapters on the organization of our Army and Navy,

the duties of the officers and men, as well as the composition of the various units should prove particularly interesting at this time. Those on the customs of the service were written specially for men who have lately entered, or who contemplate entering the military or naval life and who wish to become familiar with the etiquette and customs peculiar to such a life.''

The book explains and beautifully illustrates the insignia of the Armies and Navies of the United States, Great Britain, France, Germany, Italy, Austria-Hungary, Japan, Russia, Belgium, Turkey, Serbia, Montenegro, Roumania, Portugal, and Bulgaria, including, for the United States, the Coast Guard, Light-house Service, Coast and Geodetic Survey, etc. On the uncolored plates the colors are represented conventionally.

To any one in Washington, or near one of our camp grounds or at one of our seaport towns or commercial centres, the need of such a handy little book for officers, soldiers and civilians, men, women, and children is quite evident. The uniformed force that is gathered here and passing to and fro has bonds of interest—professional, commercial, social, or personal. We must know the branch of the service to which a man belongs, to which he is for the moment attached and his rank in the service, to understand the nature of his work and his relation to his comrades.

In our small Army and Navy a few years ago we might learn enough in a few minutes to recognize any officer or soldier we were liable to meet, but to-day we must not only study this problem carefully but need a book to which we can refer in each new situation.

Tactics and Duties for Trench Fighting. *By* Georges Bertrand, Capitaine, Chasseurs Alpins, de l'Armée de France, and Oscar N. Solbert, Major, Corps of Engineers, U. S. A. With diagrams. New York, G. P. Putnam's Sons, 1918.

xii, 230 pp., 35 plates, 3 diagrs. 17 cm.

A course of lectures delivered at the Fort Sheridan training camp, Illinois. At the earnest recommendation of the senior instructors there they have been published in this small and attractive volume. The publication has been authorized by the War Department with the indorsement that, in the opinion of the War College Division, the work has exceptional merit, presenting the principles governing trench warfare in such a clear and logical manner as to be of considerable value to our officers.

Infantry and Engineers are armed to-day not with muskets and bayonets alone, but also with automatic rifles, hand grenades and rifled grenades. A modern company is so organized, formed and maneuvered as to give full scope to the use of all these weapons. The methods now adopted are not everywhere the same. Bertram and Solbert deal with principles and examples of methods of warfare and not with fixed rules They explain and illustrate the "Company Drill Regulations adopted at Fort Sheridan, Illinois, R. O. T. C., in lieu of no existing drill regulations." They then discuss the development of a position from an open battle, sector and trench duties, the defense and attack of a position, the form of trench orders, and special operations, raids, gas, liquid fire and mines. The style is clear and attractive; the diagrams are well adapted to illustrate the text. Through the courtesy of the authors and publishers, we have been so fortunate as to reprint several of the lectures in this and former issues of the MEMOIRS.

THE MAKING OF A MODERN ARMY AND ITS OPERATIONS IN THE FIELD. A study based on the experience of three years on the French Front (1914-1917). By René Radiguet, Général de Division, Army of France. Translated by Henry P. Du Bellet, formerly American Consul at Rheims. New York, G. P. Putnam's Sons, 1918.

xiv, 163 pp., front. (port.), 1 map, 5 diagrs., plates. 19½ cm.

General Radiguet says: Divers missions sent to the United States by the Allied armies are now giving the benefit of their practical experience to the American Army. These missions are imparting to the officers of every arm the knowledge of the details it is necessary for them to acquire.

The purpose of this book is to show to the American officers, and also to the civilians who take an interest in war matters, how a large army on the European Front in the last quarter of the year 1917 is made up. . . . The perusal of this book will enable those who have sons in the European armies to follow them more intelligently through the operations in which they will soon take part.

Gen. Radiguet first gives a brief synopsis of the principal Military Operations of the Allies on the Western Front. He then analyzes War Principles for 1917, showing that the general rules of strategy and tactics have not been modified; the ways of fighting and armament only have undergone a transformation; on both

sides old methods of warfare and weapons forsaken or forgotten for centuries have again been gradually restored. He explains the normal of Composition of a Division, the real fighting unit. In his opinion, during the present war, no real success can be obtained without the help of numerous and daring aviators to direct artillery fire, and the movements of infantry, especially by comparing aerial photographs. Bombing planes should be developed. "Up to now the insufficiency of our material has been the sole reason of the failure of our aviation, to attempt the destruction of the German plants at Essen, Cologne, Manheim, Metz, etc." He gives a general account of the plan of entrenchment system, mines and counter mines, transportation, and camouflage, then of the several branches of the service.

Artillery is now the preponderant arm. He recalls General Petains motto, "the artillery conquers the positions, the infantry occupies them." The adversary that will have succeeded in silencing the opposite artillery will be sure of victory, and will obtain it without the enormous losses of human life that all combatants have sustained since the beginning of the war.

Tanks have not only been of great assistance to the British Infantry, but have produced a very depressing effect on the enemy's morale. . . . They will become more and more indispensible weapons, and their general use will save the infantry heavy loss of life.

This war has completely transformed the armament and consequently altered the fighting methods of infantry. In 1914, the French soldier was armed with a repeating gun with a hand-filled magazine. . . . Since 1914 these rifles have been replaced by others of the same model, fitted with loading clips. They are also armed with machine guns and hand grenades, which are the most powerful weapons against assaulting waves. All the Infantry use the bayonet, a weapon which has maintained its full importance in the present war. French and Russians handle the bayonet more dangerously. The Germans are not so proficient in its use. Recently (he says) General Pershing rightly laid stress on the necessity of perfecting the marksmanship of the recruit. To this accomplishment and skill in the use of the bayonet, which gives the soldier self-reliance, suppleness, and agility (qualities which the Germans do not easily acquire) ought to be added a thorough training in the handling of grenades, a sport which promptly captivates those who practice it. The trench fight is a fight to a

finish and has necessitated the adoption of a strong knife. Officers and noncommissioned officers only have automatic pistols, but he would like to see them issued to the Infantry.

"Our officers" says Gen. Radiguet, "have always and from the very first day of the war invariably marched ahead of their men, leading them straight to the enemy. . . . thousands have been killed; not one has hesitated, not one has turned back . . . The German officers endeavor to keep under shelter as long as possible their precious persons, so greatly superior, in their own estimation, to those of their men, and when they do muster courage to come out into the open they are contented to follow behind their troops, with revolvers in the hands to exact obedience."

He discusses the conduct of the attack and of the defense by the Germans and by the English, and of prolonged engagements in shell holes.

Since September, 1914, the cavalry has had but few opportunities to operate as such—but he thinks that its opportunity is bound to come.

He speaks very briefly of asphyxiating and tear-producing gases, of gaz-visciant and liquid fire.

In conclusion, General Radiguet suggests that as the Allies have delegated to the United States distinguished officers who have participated in the war and who know all its difficulties, we should then proceed, if only a short front, with an exact reproduction of the shell-torn fields over which the American troops are destined to maneuver in Europe. "The small units that could be successively and frequently trained on these prepared fields, could more frequently be sent to the Front." General Radiguet's position and reputation vouch for the accuracy of his conclusions, which are expressed so strongly as to convince the expert, and so clearly as to enlighten the layman. The vivid and attractive style in which the French excel is retained as far as practicable in the English translation. The Putnams have made of it a very attractive volume.

EDITORIAL NOTE.

As a year has now passed since the Declaration of War, a brief summary of the last six numbers of the MEMOIRS may be of interest.

In the Note in No. 49 it is stated that the duties of a military engineer include the construction of permanent and field fortification in all its branches, of roads, railroads, river, harbor works, bridges, etc. The theatre of operations, the preparation of camps and battlefields, camouflage, sapping and mining, and all technical work not especially assigned to another branch of the service.

The contents of the last six numbers are as follows:

No. of Articles.	Subject.	No. of Pages.	No. of Illustrations.
8	Construction of Field Fortifications	154	96
1	Sapping	15	23
1	Mining	17	19
11	Trench Warfare and Related Subjects	298	77
4	Transportation	115	46
9	River and Harbor Improvements	140	58
6	Memoirs of late Officers of Engineers	35	6
8	Bibliography of Articles of Engineering Interest	41	0
48		815	325

"The Influence of the European War Upon the Art of Field Fortifications," by Major Wilby in No. 46, explains the principles upon which such works are constructed, the forms they have assumed, the advantages of each form, and the methods of attack and defence under the various exigencies of a modern battle. The discussion is based upon an exhaustive study of all available sources of information, from which copious extracts are given. *"Entrenchment and Camouflage,"* by a British Officer skilled in Landscape Gardening, in No. 47, explains the same subject from his standpoint and gives a full and clear account of methods employed and suggested for concealing the works from the enemy. Accounts and discussions of Deep Gallery Shelters of the Germans, French and English are given in Nos. 46, 47 and 51. The lectures on *Sapping* and *Mining,* by Capt. A. Gay of the French Army in Nos. 49 and 50, give clear instruction about so much of the work as would usually fall to an Infantry soldier or officer to perform or to superintend.

After the subject of field work and camouflage had been so skillfully treated in Nos. 46 and 47, we were especially fortunate to have permission to print in No. 48 three chapters from *"Organization and Duties for Trench Fighting,"* by Captains Solbert and Bertrand, three of a series of lectures delivered at Fort Sheridan, Illinois, embodying the views of the officers of the French Commission on this problem. We were afterwards authorized to print two other chapters of this valuable little book. They explain and illustrate the Company Drill Regulations adopted at Fort Sheridan. They discuss the development of a position from an open battle, sector and trench duties, the defense and attack of a position, the form of trench order, and special operations, raids, gas, liquid fire and mines. The *"Suggestions on Trench Construction,"* by Captain Trounce in No. 51 treat also to some extent of trench warfare; they are valuable as the result of his experience as a Lieutenant in the Royal Engineers before he entered the U. S. Reserve Corps. *"A Visit to the English Front,"* by Captain Casajus of the Spanish Army in No. 46 and 47, which Major Swift, Chaplin, U. S. Army (ret.), has kindly translated, gives a most vivid picture of the Battle of the Somme as he viewed it in July, 1916. He explains in a clear and magnetic style his own impressions and the opinions of the British officers on all the phases of Modern Warfare. Many expressions of high appreciations have come for this article to the MEMOIRS from different parts of America. Some of the views that it expressed were quite novel when it was reprinted here. The *"German Methods of Trench Warfare,"* in 1916, is shown in No. 47 in a translation of a paper captured by the British. *"Notes on the Turkish Trenches at Sannayait,"* by Major Lang of the British Cavalry of the India Army, is interesting from the Eastern standpoint. Of all publications that treat of Trench Warfare *"The Making of a Modern Army,"* by General Radiguet, *General de Division* of the Army of France, who came here with the Commission, is one of the latest and is, perhaps, the most illuminating. It came just in time for us to reprint in the present issue (No. 51) long extracts to form a climax to the years work in the effort to place the subject of Trench Warfare before our new armies. General Radiguet discusses the conduct of the attack and of the defense on the Western Front; he takes a "glance at the Normal Composition of a Division." "A French Division includes one half-battalion of sappers and miners, which is not sufficient; two battalions at least ought to be attached to it. The rapidity and solidity with which the German entrenchments are

constructed is due to the great number of engineer battalions which our enemy possesses." Of aviation he says, "Up to now the insufficiency of our material has been the sole reason of our failure to attempt the destruction of [Germany's] plants at Essen, Cologne, Mannheim, Metz, etc." Artillery now dominates the battlefield; Cavalry has taken a small part in the war, but he thinks its opportunity is bound to come. His opinion on the conduct of modern warfare is entitled to the greatest respect.

The "*Automatic rifles, Bergman 1915, and Madsen,*" with which the German rifle battalions and light machine gun sections, respectively, have been armed, is described and illustrated in No. 48. For *Tanks,* a list of references to current periodical literature is given in No. 46. For "*Gases and Kindred Devices Applied in the Present War,*" short annotated bibliographies prepared by Mr. Haferkorn, the Librarian, are given in Nos. 48 and 49. "*Battlefield Illuminations in America,*" by Captains Kuldell and Drysdale, in No. 48, explains the use of searchlights, trench lights, rockets, bombs, flares, etc., their use in defense and offense, and examples of problems in their use by infantry and engineers. "*Military Searchlights,*" by Lieutenant Haydock, in No. 50, gives an account of semi-mobile lights used by the Italian Army in the present War. "*Zones of Silence in Sound Areas from Explosions,*" by Prof. Charles E. Munroe, in No. 50, is very interesting in connection with experiments to locate heavy guns. "*The Liaison of Divisional Engineers with Other Troops,*" is clearly explained by Major Rousseau, of the French Army, in No. 49, who, after three years' practice with the French Engineers, has spent the past year in Washington in connection with the office of the Chief of Engineers of the U. S. Army. In his article, he defines the duties of the engineers in all situations in which they are likely to serve with other troops. In the "*Use of the General Reserve in Grand Tactical Maneuvers as illustrated in the Russo-Japanese War,*" in No. 49, Colonel Mitchell explains that in some cases it may be well to employ all the forces for a fixed object. In others, especially for defense, it will certainly be best to retain a force for use in emergencies that cannot be foreseen. "*Instruction of Engineer Troops in Quarantine*" (in No. 50) describes and illustrates this practice in trench construction, bridge building, etc., with models, sand boxes, etc.

Some of the most important activities in time of war relate to Transportation. Our older officers and troops have understood and drilled in such work, and hosts of distinguished Engineers

and expert mechanics have brought to the new army the benefit of their experience in civil life. Our troops abroad have shown the world that Engineers can at the same time build roads and railroads, fortify and fight. "*Rail and Motor Transport as Applied to Military Operations,*" by Colonel Bond, in No. 49, discusses the subject from the standpoint of an experienced officer of the Corps of Engineers, "*Battle Front Transportation,*" by Lieutenant Haydock, in No. 51, from that of a civil engineer who has made a specialty of roadbuilding and carefully studied its application to military operation, especially during the present War. "*The Military Roads on the Island of Oahu,*" are described and discussed by Lieutenant Covell. "*The Road Work on the Punitive Expedition into Mexico,*" by Captain Graves, in No. 48. "*The Bridge Training of a Battalion of Mounted Engineers,*" by the Regimental Commander, in No. 50. "*How France Subsists her Armies in the Field,*" reprinted from *l'Illustration,* is explained in very attractive style.

Transportation across the sea and over the continent is as essential to the conduct of a World War as that to and from the firing line. In peace and in war, our military and civil engineers have, to this end, directed the improvement of Rivers and Harbors. The articles here relate to such work in California, in No. 47; at West Memphis, Ark., at San Francisco, and in New York, in No. 46; at Marquette, Mich., in No. 49; on the Missouri River, in No. 50.

The "*New York City's Catskill Mountain Water Supply,*" by Mr. Flinn, Deputy Chief Engineer of the Board, describes one of the greatest works of its kind ever constructed. We were very glad for permission to reprint it, as possibly suggesting methods that may be useful in our mining, or in our river and harbor operations.

Each number contains a portrait and a very short sketch of the life of some distinguished officer of the Corps of Engineers.

Each number contains a Bibliography prepared by Mr. Haferkorn.

Most of the subjects mentioned in the former note have thus been treated in the six war numbers. The main object has been to present the latest views of experts in each branch, and to make all the subjects clear and attractive to the citizen and the soldier.

Errata.

In No. 49, page 128, line 7, instead of "Sheeted Frame" read Cased Frame.

In No. 50, on Contents Page (iii) and page 192, read Burslem instead of Burlem.

In No. 51, page 342, line 3, instead of "trucks" read trains.

AERIAL PHOTOGRAPHY.

BIBLIOGRAPHY OF AVAILABLE MATERIAL RELATING TO THE MEANS, METHODS, EXPERIMENTS AND RESULTS OF AERIAL PHOTOGRAPHY. PREPARED IN THREE PARTS, EACH PART WITH AN INDEX, BY MR. HENRY E. HAFERKORN, ENGINEER SCHOOL LIBRARY, WASHINGTON BARRACKS, D. C., APRIL-MAY, 1918.

TABLE OF ARRANGEMENT.

PART I.

Photo-topography, including Photo-grammetry (Metro-photography), Stereosscopy, etc., and kindred subjects, as applied to Surveying from Balloons, or other aircraft, or from elevations or from a distance.

PREFATORY NOTE.

The attempt of preparing a practical guide to the investigations and experiments, made during the last 40 years, in the study of Aerial Photography has met with quite a few difficulties, more especially because the means and methods for practical application were factors of importance not to be overlooked.

Besides, the collection of the vast material, widely scattered among various forms of serial publications, was found to be a considerable task, more particularly because most of it was not available in local libraries.

While no effort was made to present a complete list of all publications on the subject, the aim was to include the most important writings of the leading investigators in this study, as far as possible under the prevailing circumstances.

The material found has been carefully examined, and besides a full title-entry, in almost every case, short notes have been added when they were considered to be of value.

The student will find additional material listed in the Index, under the heading Bibliography.

It is hoped that the general arrangement of the material will meet with the approval of the student as well as with the practical worker in these fields and prove to be of practical value to them in their research work.

TABLE OF ARRANGEMENT.

ABBREVIATIONS.

The initials at the end of titles refer to Libraries where the publication will be found, viz.: AW: Army War College, Washington Barracks, D. C.; CA: U. S. Coast Artillery School Library, Fort Monroe, Va.; CG: U. S. Coast and Geodetic Survey, Washington, D. C.: ES: Engineer School Library, Washington Barracks, D. C.; FS: Library, U. S. Forest Service, U. S. Dept. of Agriculture, Washington, D. C.; LC: Library of Congress, Washington, D. C.; ND: Library, U. S. Navy Dept., Washington, D. C.; NM: U. S. National Museum, Washington, D. C.; PO: Patent Office, Scientific Library, Washington, D. C.; Sm: Smithsonian Institution, Washington, D. C. WB: U. S. Weather Bureau, U. S. Dept. of Agriculture, Washington, D. C. Titles to which no initials are affixed have not been located in Libraries available to us, but a number of these publications have been loaned by various students of the subject, and the greater number have been carefully examined. In the case of material found on the shelves of the L. C. it has been deemed convenient to add the call-numbers, which follow the initials in parenthesis. For periodicals and other serial publications the following abbreviations have been used, viz.:

Aër.: L'Aéronaute, Paris.

Aër. Club: Aero-Club Suisse. Schweizerischer Aero-Klub, Bern. Bulletin.

Am. I. M. E.: American Institute of Mining Engineers, New York. Transactions. Bulletin.

Brit. J. P.: British Journal of Photography, London.

Centralbl. F.: Centralblatt für das gesammte Forstwesen. Hrsg. von Ingenieur Karl Böhmerle . . . Wien, Verlag von Wilh. Frick.

Conq. L'Air: La Conquête l'Air, Bruxelles, Belgium.

D. Luftf. Z. B.: Deutsche Luftfahrer Zeitschrift, Berlin.

D. Luftf. Z.: Wien . . . Deutsche Luftfahrer Zeitung, Wien.

Eng.: Engineering, London.

Eng. N.: Engineering News, New York. (Now changed to Engineering-Record, New York.)

Génie C.: Le Génie Civil, Paris.

Illus. aer. M.: Illustrirte aeronautische Mittheilungen, Strassburg.

Inst. Civ. E.: Institution of Civil Engineers, London. Minutes of proceedings.

Int. Arch. P.: Internationales Archiv für Photogrammetrie. Verlag von Carl Fromme, Wien.

Kais. Akad. W., W.: Kais. Akademie der wissenschaften, Wien. Sitzungsberichte der mathematisch-naturwissenschaftlichen klasse.

K. K. Geog. G., W.: K. K. Geographische gesellschaft, Wien. Mittheilungen.

K. Akad. W., M.: K. Akademie der wissenschaften, Munich. Abhandlungen. II. Klasse.

Mar. C. Gaz.: Marine Corps Gazette, Washington, D C.

Mem. Art.: Memorial de artilleria, Madrid.

Mém. O. G.: Mémorial de l'Officier du Génie. Gauthier-Villars, Paris.

Mil. Service I.: Military Service Institution of the United States, Governor's Island, N. Y. H.

Mittheil. G. A. G.: Mittheilungen über gegenstände des artillerie-und genie-wesens, Wien.

Petermanns M.: Dr. Petermann's mittheilungen aus Justus Perthes' Geographischer Anstalt, Gotha.

Photog. A.: Photographisches Archiv, Berlin.

Photog. Cor.: Photographische correspondenz, Wien.
Photog. R.: Photographische Rundschau, Halle, a. S.
Photog. Woch.: Photographisches wochenblatt, Berlin.
Photo-Min.: Photo-miniature, London and New York.
Polyt. Centralbl.: Polytechnisches centralblatt, Leipzig.
Rev. C. Mil.: Revista de circulo militar, Buenos Aires, Arg. Republic.
Rev. du G. M.: Revue du génie militaire, Paris.
Rev. Geog. A.: Revue de géographie annuelle, Paris
Riv. Art. G.: Rivista di artiglieria e genio, Roma, Italy.
Riv. Mar.: Rivista Marittima, Roma, Italy.
Science V.: La science et la vie, Paris.
Soc. Aer. Ital.: Società aeronautica italiana, Bolletino.
Soc. F. Phot.: Société francaise de photographie, Paris. Bulletin.
Soc. Geog.: Société de géographie, Paris.
South A. P. S.: South African philosophical society, Johannisburg. Transactions.
Tech. Aer.: Technique aéronautique, Paris.
U. S. Geo. S.: United States Geological Survey, Washington, D. C. Bulletin.
Wien. L. Z.: Wiener luftschiffer-zeitung, Wien.
Zeitsch. B. Zeitschrift für bauwesen, Berlin.
Zeitsch. Verm.: Zeitschrift für vermessungs-wesen, Stuttgart.

A. BIBLIOGRAPHY (GENERAL).

For additional bibliographical material see index.

1 Boffito, Giuseppe.

Saggio di bibliografia aeronautica italiana, con una dissertazione di A. M. Cortenovis ripubblicata in appendice da E. Vajna de Pava. Firenze, L. S. Olschki, 1906.

37 p. pl. 29½ cm. (Pubblicazioni dell' Osservatorio del Collegio alla Querce [Firenze] ser. in 4°—n.° 13.)

Plate printed on both sides.

"Estratto dal vol. vii, disp. 11a, 12a, e dal vol. viii, disp. 1a, 2a-3a, e 4a-5a della Bibliofilia diretta dal comm. Leo S. Olschki."

Querce [Firenze] ser. in 4°—n.° 17.)

Saggio di biliografia aeronautica italiana. Correzioni ed aggiunte tratte dalle schede del . . . dottor Diomede Buonamici. Firenze, Presso la Direzione dell' Istituto alla Querce, 1908.

1 p. l., 18 p. 29½ cm. (Pubblicazioni dell' Osservatorio del Collegio alla

"Estratto dal vol. viii, disp. 10a-11a e dal vol. ix, disp. 1a-2a, 4a, 5a, 6a-7a 8a della Bibliofilia . . . ." LC. (Z5063 B65.)

2 Brockett, Paul.

Bibliography of aeronautics, by Paul Brocket . . . Wash., Smithsonian institution, 1910.

xiv, 940 p. 24½ cm. (Smithsonian miscellaneous collections. v. 55. Publication 1920.)

At head of title: Hodgkins fund. LC. (Q11 S7, v. 55, and Z5063 B85.)

3 Gt. Brit. Patent Office. Library.

Subject list of works on aerial navigation and meteorology, in the

Library of the Patent office, London, Printed for H. M. Stationery off., 1905.

63, [1] p. 16½ cm. (Patent office library series: no. 17. Bibliographical series: no. 14.) LC. (Z5063 G85.)

4 INTERNATIONALES ARCHIV FUER PHOTOGRAMMETRIE.

Organ der Oesterreichischen gesellschaft für photogrammetrie in Wien . . . Redigiert von Eduard Dolezal . . . Wien und Leipzig, Kais. und königl. Hof-Buchdruckerei und hof-verlags-buchhandlung Carl Fromme, 1908.

v. incl. illus., diagrs., maps, plates, ports. 25 cm. Band 1, heft 1, März, 1908.

Each number contains: Bibliographie, and reviews of new publications.

"Vier bis fünf hefte zu vier bis fünf bogen bilden einen band. Jährlich höchstens ein band."

5 KUEHL, W. H. BERLIN.

Aëronautische bibliographie. Verzeichnis älterer und neuerer bücher und abhandlungen über theoretische und praktische luftschiffahrt, militär- und marine-aëronautik, flugtechnik, vogelflug, dynamische und aëronautische luftschiffe, sowie der damit zusammen-hängenden wissenschaften . . . Zusammengestellt und zu beziehen durch W. H. Kühl . . . Berlin [Lippert & co., Buchdr., 1895].

51 p. 15½ cm.

Cover-title: Aeronautische bibliographie, 1670-1895.

Aëronautische bibliographie. ii. 1895-1902 . . . Berlin [Druck von J. S. Preuss], 1902.

Cover-title, [3]-22 p. 18½ cm. LC. (Z5063K96.)

6 PARIS. BIBLIOTHEQUE HISTORQUE DE LA VILLE.

Catalogue des publications et des manuscrits composants la collection Nadar [pseud.] à la bibliothèque. (In its: Bulletin de la bibliothèque et des travaux historiques. Paris, 1913. 24½ cm. no. vi, p. [1]-7, col. 8-1241.)

''Nadar'' (Felix Tournachon) collection of works on aëronautics. LC (Z2184 P2P35 no. 6)

7 RUNDSCHAU FUER STEREOPHOTOGRAMMETRIE.

Bi-monthly. Editor: S. Truck. . . . Wien, 1910.

First number dated March 1, 1910.

For the program of this publication see: Internationales archiv für photogrammetrie, Wien.

Band ii, heft 2, Oct., 1910, p. 140-142.

8 SCHWEIZERISCHER AERO-CLUB, BIBLIOTHEK.

Bibliothek-katalog des Schweizer. aero-club. Catalogue de la bibliothèque de l'Aero-club suisse. Bern, 1915.

xii, 76 p. 20½ cm.

Preface, contents, library regulations, captions, etc., in German and French. LC. (Z5064 S38.)

9 TISSANDIER, GASTON.

Bibliographie aéronautique: catalogue de livres d'histoire, de science, de voyages et de fantaisie, traitant de la navigation aérienne ou des aérostats, par Gaston Tissandier. Paris, H. Launette et cie., 1887.

2 p. l., [5]-62, [2] p. 29 cm.

Contains over 800 titles.

"Il a été fait une édition spéciale à vingt-cinq exemplaires numérotés sur papier du japon." LC. (Z5063 T61.)

B. BOOKS AND SEPARATE IMPRESSIONS.

10. BECK, R. AND J. LTD.

Practical notes on tele-photography. (Beck-Steinheil telephoto lens.) By R. and J. Beck, lts., 68 Cornhill, London, E. C. 2d edition. 11th thousand. Lond., 1901.

1 p. l., 48 [1] p. Illus., diagrs., front., 1 fold. plate (half-tone). 8x16½ cm.

11 BREED, CHARLES BLANEY.

The principles and practice of surveying . . . by C. B. Breed and George L. Hosmer . . . N. Y., J. Wiley & sons, inc., [etc., etc.], 1917.

2 v. illus., maps (part fold), tables, diagrs. (part fold). 19 cm.

LC. (TA545 B82) 1917. ES.

Contents.—v. 1. Elementary surveying. 4th ed. . . . v. 2. Higher surveying. 2d ed.

v. 2, chap. vi. Photographic surveying, p. [224]-245.

12 CANADA. DEPT. OF THE INTERIOR. SURVEYS BRANCH.

Manual of instructions for the survey of Dominion lands. Issued by the authority of the Hon. the Minister of the interior. Ottawa, Govt. printing bureau, 1910.

xxiv p. 1 l., 3-183 p. incl. illus., tables, diagrs. and portfolio of 11 maps. 20 cm. ES.

The same. Supplement . . . Toronto, W. Briggs, 1908. vii, 9-124 p. incl. tables, diagrs. 19 cm. ES.

13 CARLOCK, FLOYD D.

Military topography and photography. Menasha, Wis., Geo. Banta pub. co., [c1916].

x, 310 p. illus., diagrs. 24 cm. LC. (UG470. C3.) ES.

Aero-photography, p. 196. Scheimpflug camera, p. 198. Scheimpflug-Kammerer perspectograph, p. 199.

14 CHEVALLIER, AUGUSTE.

Application de la photographie à la topographie militaire. Notice sur la planchette photographique, avec note de M. Paté.—Rapport de M. d'Abbadie. Paris, J. Dumaine, 1862.

15 CLOSE, CHARLES FREDERICK.

Text book of topographical and geographical surveying, by Col. C. F. Close. Rev. by Capt. E. W. Cox. 2d ed. Lond., Printed under the authority of H. M. Stat. off., 1913.

v, 412 p. front., illus., xli pl. (incl. maps, charts, diagrs.) 27½ cm. AW. ES.

Appendix J. Photographic surveying, p. 395-397.

16 CONFERENCE DE LA COMMISSION.

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Procès-verbaux des séances et mémoires. Strasbourg, imprimerie M. Du Mont Schauberg, 1907.

xiv p. 1 l., 133 p. incl. illus., diagrs., tables. 1 plate (diagr., part fold). 25 cm. (At head of title: R°. Ufficio centrale di meteorologia e geodinamica in Roma. WB.

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For fuller entry see each memoir under the authors' name.

17 CONGRES INTERNATIONALE D'AERONAUTIQUE, 3e, MILAN, 22-28 OCTOBRE, 1906.

Rapports et mémoires publiées par les soins de la Commission permanente internationale d'aéronautique. Paris, H. Dunod et E. Pinat, 1907. 17 plates.

18 CONFERENCES PUBLIQUES SUR LA PHOTOGRAPHIE THEORIQUE et technique, organisées en 1891-1892, par le directeur du Conservatoire nationale des arts et métiers. Paris, Gauthier-Villars, 1893.

198 figs. 9 pl. 24 cm.

19e Séances. chap. 9. Fribourg. La photographie militaire et la photo-cartographie.

19 DALLMEYER, THOMAS R.

Telephotography; an elementary treatise on the construction and application of the telephotographic lens. With twenty-six plates and sixty-six diagrams. London, W. Heinemann, 1899.

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20 DEVILLE, ÉDOUARD GASTON DANIEL.

The copying camera of the Surveyor general's office. By E. Deville. Ottawa, Govt. printing bureau, 1912.

40 p. incl. illus., diagrs., tables. 26 cm. ES.

21 DEWIDELS, EGON.

Die aufnahme von Neuland durch aerophotogrammetrie Von Diplom.-ingenieur Egon Dewidels. Allgemeine ingenieur-zeitung, Wein. Nos. 9, 10, 1913.

(Sonderabdruck. Ueberreicht von Theod. Scheimpflug, Aerogrammetrie, Wien.)

22 DOCK, HANS.

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130 p. illus., diagrs. 16 cm. (Sammlung Göschen, [699].)

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23 DOLEZAL, EDUARD.

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Caption-title. 22 p. incl. illus., diagrs. 20 cm. (Separat-abdruck aus Jahrbuch für photographie und reproductionstechnik für das jahr 1899, von regierungsrath Dr. Jos. Maria Eder.)

24 DOLEZAL, EDUARD.

Arbeiten und fortschritte auf dem gebiete der photogrammetrie im jahre 1899. Von E. Dolezal, k. k. o. ö. prof. an der k. k. Bergakademie in Leoben.

caption-title. 27 p. incl. illus., diagrs. 20 cm. (Separatabdruck aus Jahrbuch für photographie und reproductionstechnik für das jahr 1900. Von Hofrath dr. Jos. M. Eder.)

25 DOLEZAL, EDUARD.

Arbeiten und fortschritte auf dem gebiete der photogrammetrie im jahre 1900. Von E. Dolezal, o. ö. prof. an der k. k. Bergakademie in Leoben. Halle, a. S., Wilh. Knapp, [1901].

caption-title. 47 p. incl. illus., diagrs. 20 cm. (Separatabdruck aus Jahrbuch für photographie, etc., für das jahr 1901. Hrsg. von Hofrath dr. Jos. M. Eder.)

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Contents.—1. Phototopographie, p. 20-32. 2. Photogrammetrie für technische zwecke, p. 33-38. 3. Photogrammetrie in der meteorologie, p. 38-45. 4. Ballonphotogrammetrie, p. 45-51. 5. Photogrammetrie bei serienmomentaufnahmen und in der ballistik, p. 52-57. 6. Photogrammetrie in der Marine und oceanographie, p. 57-60. 7. Photogrammetrie in der astronomie, p. 60-68. 8. Photogrammetrie im dienste der denkmalpflege und archäologie, p. 68-75. 9. Photogrammetrie für forschungsreisende, p. 75-76.

Plate i. Universal-phototheodolit von professor dr. Anton Schell. Photogrammeter des baron Hübl. ii. Karte einer partie des Triglavgebietes. Militär- mappierung. Massstab 1:25000.

27 DOKULIL, TH.

Die stereophotogrammetrischen instrumente der firma Carl Zeiss in Jena. Von Ingenieur dr. Th. Dokulil, privatdozent und adjunkt an der k. k. Technischen hochschule in Wien. (Separat-abdruck aus der fachzeitschrift ''Der Mechaniker,'' Berlin, F. und M. Harrwitz, 1909.)

See review of the above in: Internat. archiv für photogrammetrie, Wien. Band 2, heft 4. Oct., 1911, p. 304. Signed D.

28 ELIOT, MARK ESKINE YORKE.

Tacheometer surveying, with special notes on plotting, care and adjustment of instruments, field work, and calculations. With 1 plate and 30 illus. Lond. E. & F. N. Spon; N. Y., Spon and Chamberlain, 1916.

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29 FABRE, CHARLES.

Traité encyclopétique de photographie. 4e supplement D. Paris, Gauthier-Villars, 1916.

4e fascicule, 15 oct., 1906. Livre iii. Photogrammes (photocopies), p. [752]-809.

30 FEVRE, CHARLES THEODORE.

Notice sur une nouvelle planchette de reconnaissance militaire, inventée par M. Fèvre, Chef d'escadron d'état-major. Paris, J. Dumaine, 1863. 2 plates. 23 cm.

31 FINSTERWALDER, SEBASTIAN.

Eine neue art die photogrammetrie bei flüchtigen aufnahmen zu verwenden. München, G .Franz's verlag, 1904. p. 103-111. 2 figs. 23 cm.

32 FINSTERWALDER, SEBASTIAN.

Photogrammetrie. (In: Encyklopädie der mathematischen wissenschaften, Leipzig. v. 6-i, no. 1, 1906.) LC. (In: QA36. E56, v. 6.)

33 FINSTERWALDER, SEBASTIAN.

Die photogrammetrie als hilfsmittel der geländeaufnahme. (In: Anleitung zu wissenschaftlichen beobachtungen auf reisen, hrsg. George Balthasar von Neumayer. 3. auflage. Hannover, Jaenecke, 1916.)

34 FLEMER, JOHN ADOLPHUS.

An elementary treatise on phototopographic methods and instruments,

including a concise review of executed phototopographic surveys and of publications on this subject, by J. A. Flemer . . . 1st ed. N. Y., J. Wiley & Sons; [etc., etc.], 1906.

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Plates, with the exception of the last, printed on both sides.

LC. (TA593 .F59) ES.

"Literatur," p. 9-34.

Contents.—i. Short review of executed photographic surveys and lists of the more important publications on photogrammetry and phototopography, p. 5-35.—ii. The elements of perspective (central projection), p. 35-41.—iii. Pin-hole photography, p. 42-46.—iv. Fundamental principles of iconometric map-plotting ("Iconometry"), p. 47-75.—v. Photographs on inclined plates, p. 78-81.—vi. Photographic surveying methods, p. 83-158.—vii. Camera lenses, p. 159-181.—viii. Photogrammeters or photogrammetric instruments, p. 183-269.—ix. Panorama cameras, p. 270-274.—x. Iconometers and perspectographs p. 275-333.—xi. Photographic operations in the field, p. 335-386.—xii. Conclusion and remarks on the precision of the "Polar iconometric method" and general remarks on telephotography, p. 387-407.

[Literature on Telephotography], p. 407.

Index, p. 409-438.

Note.—Special attention may be called to the very extensive list of publications of the subjects treated, on p. 9-34.

See also review of this work by D. (Dolezal) in: Internat. archiv für photogrammetrie, Juli, 1908, p. 147-149.

35 Flemer, John Adolphus.

Phototopographic methods and instruments, By J. A. Flemer, Assistant. (Report, Supt. of the U. S. Coast and geodetic survey, 1897. Appendix no. 10, p. 619-735, incl. illus., diagrs., 2 plates.

ES. LC. (UB296 U8, 1897.)

Contents.—i. Fundamental principles of iconometry. ii. Photographs of inclined planes. iii. Phototopographic methods. iv. Photogrammeters. v. Iconometers and perspectographs.

References to the literature on the subject are intersperced throughout the text.

36 Flemer, John Adolphus.

Photography as practices in Italy under the auspices of the Royal military geographical institute, and as practiced in the Dominion of Canada under the auspices of the Department of the interior. Also, a short historical review of other photographic surveys and publications on the subject. Submitted for publication, Dec. 9, 1893, by J. A. Flemer, assistant. (Report, Supt. of the U. S. Coast and geodetic survey, 1893, pt. ii. Appendix 3, p. 37-116, incl. illus. diagrs. tables. 2 plates.

ES. LC (UB296 U8, 1893-2.)

Contents.—Preface.—Introduction. i. The photogrammetric apparatus. ii. Principles of phototopography. iii. The execution of the fieldwork. iv. The horizontal projection. v. The hypsometrical work. Supplement. Model no 1, no 2.—Photographic instruments and methods employed for topographic surveys in the Dominion of Canada.

"Short review of photographic surveys and publications," p. 38-45.

37 Hilderbrandt, Adolf.

Die luftschiffahrt nach ihrer geschichtlichen und gegenwärtigen entwickelung. 2. verm. und verb. aufl. Mit einem titelbild (erste farbenphotographie vom ballon aus, von prof. Miethe) und 292 text-abbildungen. München, und Berlin, R. Oldenbourg, 1910.

vi, 1 l., 456 p. col. front, illus. 25 cm. LC. (TL545 .H65.)

Kap. 21. Ballonphotographie, p. .[396]-402.—kap. 22. Photographisches material für ballonzwecke, p. [403]-407.—kap. 23. Das lesen von photogrammen, p. [408]-413.—kap. 24. Das photographieren mit apparaten, die vermittelst drachen oder brieftauben hochgeführt werden. p. [414]-418.—kap. 25. Auswertung von photogrammen, p. [419]-421.—kap. 26. Brieftauben für ballonzwecke, p. [422]-429.

Frontispiece is a reproduction of a photograph in colors, taken by Prof. Dr. Miethe, at a height of 850 m.

38 HILDEBRANDT, ADOLF.

Airships past and present, together with chapters on the use of balloons in connection with meteorology, photography and the carrier pigeons. Trans. by W. H. Story, N. Y., D. Van Nostrand co., 1908.

xvi, 364 p. illus. (incl. ports, maps, fascims.), double-plates. 24 cm.
LC. (TL545 H66.)

Printed in Great Britain.

Contents. . . . xvii. Instruments. xx. Balloon photography. xxi. Photographic outfit for balloon work. xxii. The interpretation of photographs. xxiii. Photography by means of kites and rockets. xxiv. Problems in perspective. xxv. Carrier pigeons for balloons.

39 HOERNES, HERMANN.

Buch des fluges. Unter mitwirkung von k. k. rat von Angeli [u. a.], hrsg. von Hermann Hoernes. 1.-2. band. Wien, G. Szelinski, 1911.

2 v. illus., pl. (part col., part fold). col. port., fold, map, diagrs. (part fold). 28 cm. LC. (TL545 H7.)

Each vol. has also special t.-p.

40 JOUART, A.

Applications de la photographie aux levés militaires. Par A. Jouart, lieutenant d'artillerie. Paris, J. Dumaine, 1866. 2 plates. 23 cm.

41 KAMMERER, G.

Th. Scheimpflug's landvermessung aus der luft. Von G. Kammerer, Ingenieur in Wien. (Sonderabdruck aus Internationales Archiv für Photogrammetrie, Wien, band 3, heft3, p. 196-226. 16 illus.)

42 KIESLING, MARTIN.

Die anwendung der photographie zu militärischen zwecken. Bearbeitet von Kiesling, Premier-lieutenant a. d. Mit 21 figuren in text. Halle a. S., W. Knapp, 1896.

vi, p. 1 l., 100 p. front, illus., diagr. 22 cm. (Encyklopädie der photographie. heft 19.) LC. (TR785 K6.)

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Contents: Vorwort, p. v. Einleitung, p. 1. Die anwendung . . . p. 5. 1. Vervielfältigung von karten, plänen, u. s. w. 2. Photogrammetrie, p. 15. 3. Ballonphotographie, p. 36. 4. Drachenphotographie, p. 47. 5. Raketen-photographie, p. 51. 6. Fernphotographie, p. 52. 7. Rekognoszirungs-photographie, p. 53. 8. Mikroskopische photographie, p. 63. 9. Mikro-photographie, p. 70. 10. Photographie fliegender geschosse, p. 70. 11. Photographie der pendelungen der langgeschosse, p. 79. 12. Photographie der geschoss-wirkungen, p. 82. 13. Photographie des rücklaufs der geschütze, p. 84. 14. Photographie springender minen und hohlgeschosse, p. 84. 15. Serien-photographie, p. 87. Schlusswort, p. 95. Anmerkungen, p. 97.

43 KUTTA, W.

Photographic surveying from balloons. By prof. dr. W. Kutta. (In: Moedebeck, Herm. W. L. Pocketbook of aeronautics . . . Authorized English edition. Trans. by W. Mansergh Varley. Lond., Whittaker & co., 1907. chap. 8, p. [202]-216. figs. no. 64-77.) Sm.

44 LAN-DAVIS, CYRIL F.

Telephotography. With sixteen full page plates and seven diagrams. London, G. Routledge & Sons, limited; New York, E. P. Dutton & co., [1912].

xi, 130 p. incl. illus., plates, diagrs. 20 cm. ES. LC. (TR770 .L3.)

45 LAUSSEDAT, AIME.

La métrophotographie. Paris, Gauthier-Villars, 1898 incl. figs. 2 plates. 20 cm.

46 LAUSSEDAT, AIME.

Recherches sur les instruments, les méthodes, et le dessin topographiques, par le colonel A. Laussedat . . . Paris, Gauthier-Villars, 1898-1903.

2 v. in 3. illus., 32 pl. (22 fold.), 6 fold., maps, 9 plans (8 fold.), tables, diagrs. 26 cm. ES. LC. (TA545 L38.)

Contents. t. i. Chap. i. Aperçu historique sur les instruments et les méthodes. Appendice du chapitre i. Instruments et méthodes à l'usage des explorateurs et utilisables en topographie. chap. ii. La topographie dans tous les temps; vues pittoreques et plans géométriques.

t. iii, ptie. 1. chap. iii. Iconométrophotographie. Méthodes. Instruments. Métrophotographie. Appendice au chap. iii. Sur le rôle des observatoires militaires pendant le Siège de Paris par les armées allemandes.—Commissaires militaires.—Astronomes et physiciens. Ingénieurs artistes de précision et volontaires de professions diverses.

Planche iii. Première épreuve photographique obtenue en aérostat 18581 par Nadar.

Planche v. Tour d'horizon fait avec la planchette photographique du Dr. Chevallier . . . Tour d'horizon fait avec le périgraphe instantané du colonel Mangin.

Planche vii. Restitution au moyen de deux vues dessinées à la chambre claire.

Planche ix. Chambre claire hémi-périscopique montée sur la planchette.

Planche xi. Chambre noir topographique. t. ii, ptie. 2. chap. iv. Developpement en progres de la metrophotographie à l'étranger et en France. Methods et instruments de déssin.—Innovations principales proposées.—Du parti que l'on peut tirer des photographies obtenues dans des circontances exceptionnelles ou même de celles que l'on trouve dans le commerce.—Reconnaissances photographiques faites de stations plus ou moins éloignées.—Téléphotographie.—La photographie en ballon.—Photographie par cerf-volant.—La stéréoscopie appliquée à La construction des plans.—Notes, rectificatives.

Planche i. Vues stéréoscopiques obtenues par le Dr. Pulfrich.

Planche ii. Perspectographe de Guido Hauck.

Planche iii. . . . Perspectographe de M. Ch. von Ziegler.d'après le plan nivelé de M. le capt. Javary.

Planche ix. Vue de Bâle prise en ballon, à 400 m au-dessus du Rhin, par M. Suter.

Planche x. Restitution photogrammétrique d'après des vues prises en ballon, par M. S. Finsterwalder.

Planche xi. Vue de Labruguière (Tarn) prise à l'aide d'un cerf-volant, par M. Arthur Batut.

Planche xii. Vue de Berck-sur-Mer prise à l'aide d'un cerf-volant, par M. Wenz.

Planche xvi. Appareil stéréoscopique pour la construction de plans topographiques.

47 MARRIAGE, ERNEST.

Elementary telephotography. London, 1901.

48 MOESSARD, P.

Appareil photographique panoramique; le cylindrographe. Par P. Moës-

sard, Capitaine du génie, professeur de topographie à l'École de Saint-Cyr. Paris, Delagrave, 1885. 20 cm.

49 MOESSARD, P.

Le cylindrograph; appareil panoramique. Par P. Moëssard, Commandant du génie breveté, . . . Avec figures, contenant chacun une grande planche photocollographique. Paris, Gauthier-Villars, 1889.

2 v. incl figs., plate. 19 cm.

Contents.—Ier ptie. Le cylindrographe photographique. Chambre universelle pour portraits, groupes, paysages et panoramas. iie ptie. Le cylindrographe topographique. Application nouvelle de la photographie aux levés topographiques.

50 NUGENT, PAUL COOK.

Plane surveying. A text and reference book for the use of students in engineering and for engineers generally. 3d rev. ed. N. Y., J. Wiley & sons; [etc., etc.], 1911.

xxii, 599 (i. e. 613) p. incl. illus., tables. viii pl. (part fold., incl. map, plans, diagrs.). 23½ cm. 3.50. ES. LC. (TA545 .N9, 1911.)

Appendix D. Phototopographic methods and instruments, p. 421-473.

51 PAGANINI, LUIGI PIO.

Apparato fototopografico per levate rapide al 50,000 e 100,000. Modello 1897. (Dalla Rivista marittima, fascicolo agosto-settembre, 1897.)

caption-title. 9 p. incl. 1 diagr., 2 plates (part fold.). 25 cm. (Estratto dalla Rivista di topografica e catasto, v. xi.)

Signed: Ing. Pio Paganini.

Plates: Apparato fototopografico Paganini per levate speditive alla scala di 1:50000 e 1:100000. Modello 1897.

52 PAGANINI, LUIGI PIO.

La fototopografia in Italia. Per Luigi Pio Paganini, ingegnere dell' Istituto geografico militare. Estratto dalla Rivista di topografia e catasto. Roma, G. Civelli, 1889.

2 p. l., [6]-41 p., incl. 20 illus., figs., tables, 2 photographs, 2 fold. maps. 24 cm. CG.

Contents.—Cenni generali. i. Vicende della fotografia in Italia. ii. Apparecchio fototopografico. Elementi della prospettiva. iii. Relazioni fra i vari elementi della prospettiva e principi sui quali é fondato il rilievo fototopografico. iv. Pratica dei lavori di campagna. v. Pratica del rilievo planimetrico. vi. Pratica del rilievo altimetrico. Conclusione.

With bibliographical foot-notes.

53 PAGANINI, LUIGI PIO.

Fotogrammetria. Fototopografia pratica in Italia e applicazione della fotogrammetria all' idrografia. Con 56 figure e 4 tavole intercalate nel testo. Milano, Ulrico Hoepli, 1901.

3 p. l., [vii]-xv-[xvi], 288, 64 p. incl. illus., diagrs., forms. iv plates (part fold.). 16 cm. (At head of title: Manuali Hoepli.)

"Bibliografia," p. [275]-288.

[Appended]: 700 Manuali Hoepli, p. [1]-64.

54 PAGANINI, LUIGI PIO.

Nuovi appunti di fototopografia. Applicazioni della fotogrammetria all' idrografia. Seguits alla nota "La fototopografia in Italia." Pubblicata nella Rivista Marittima, fasc. di giugno e luglio 1889. Roma, Forzani e c., tipografi del senato, 1894 (Rivista marittima, estratto dal fascicolo di marzo 1894).

3 p. l., [6]-41 p. 1 illus., 3 fold. pl. (diagrs.). 20 cm. CG.

With bibliographical foot-notes.

55 PAGANINI, LUIGI PIO.

Del rilevamento fototopografico. Relazione dell' ingegnere P. Paganini. Genova Tip. Sordo-muti [1892].

caption-title. 22 p. 1 fold. map. 24 cm. (Estratto dagli Atti del primo Congresso geografico italiano Genova 1892.) CG.

Signed: Susa, 5 agosto 1892.

Map: Passo di Spluga. Fe. 6 e 7 della carta d'Italia. F°. 6. i. ii. cF°7, iii. iv. Scale 1:50000m. L'equidistanza della curve é di metri 50. (Per le curve punteggiate di metri 10.)

PAGANINI, P.

See Paganini, Luigi Pio.

56 PATE, EDOUARD.

Application de la photographie à la topographie militaire. Notice sur la planchette photographique de M. Auguste Chevalier, ancien médecin requis à l' hôpital militaire du Gros-Caillou; avec l'indication des méthodes connues de topographie, qui s'appliquent à cet appareil. Par E. Paté lieutenant au 2e régiment du génie. Paris, J. Dumaine, 1862.

Fig., plates. 23 cm. (Extrait du Bulletin de la Société de géographie, dec., 1862.) LC. (G11 S4. 1862.)

See also: Abbadie, A. d'.

57 PELLETAN, A.

Traité de topographie. 2e édition, revue et considérablement augmentée. Avec 348 figures, dessins geometriques, dessins d'instruction, et diagrammes. Paris, Ch. Béranger, 1911.

[iv]+iv, 528 p. 348 figs. 24 cm.

Photogrammetrie, p. 481-511.

1st edition, 1893. xix, 381 p. figs. ibid.

58 PERALTA, R.

Fototaquimetria nuevo procedimiento de topografia fotografia. Madrid, Memorial de ingenieros, 1901.

32 p. 2 plates. 25 cm.

See review of this work in: Revue du génie militaire, Paris. t. xxii, p. 473.

59 PIZZIGHELLI, GIUSEPPE.

Handbuch der photographie für amateure und touristen. Hrsg. von G. Pizzighelli. Halle a. S., W. Knapp, 1891-1903.

3 vols. illus., plates, diagrs. 25 cm. LC. (TR145 .P74.)

Each volume has also special t.-p. Bibliographies at end of sections.

Band 1. Die photographischen apparte. 1891. xii, 685 p. 531, illus.—*bd.* 2. Die photographischen processe. 3. verb. aufl., bearbeitet von Curt Mischewski. xii, 539 p. 221 illus., 1903.—*bd.* 3. Die anwendungen der photographie. 1892. x, 496 p. 284. illus.

Band iii. Kapitel vii. Die photogrammetrie. 1. Die principien der photogrammetrie, p. 166-175.—2. Die photogrammetrischen apparate, p. 175-193. A. Die für photogrammetrische arbeiten adaptirte gewöhnliche camera von Le Bon, p. 177-179.—B. Die für photogrammetrische arbeiten adaptirte gewöhnliche camera von F. Schiffner, p. 179-182.—C. Der photogrammetrische apparat von Dr. H. W. Vogel und Dr. Dörgens, p. 182-184.—D. Der photographische theodolit von B. Meydenbauer, p. 184-185.—E. Der photogrammeter von Hafferl und Maurer.—F. Der phototheodolit von Dr. Koppe, p. 185-188.—G. Der photographische theodolit von L. P. Paganini, p. 188-189.—H. Der phototheodolit von V. Pollack, p. 189-191.—I. Der Cylindrograph von Moëssard, p. 191-193.—3. Allgemeiner vorgang bei photogrammetrischen aufnahmen. A. Die photogrammetrischen terrainaufnahmen, p. 193-200.—B. Die photogrammetrischen aufnahmen von bauwerken, p. 201-202. 4. Daten über den entwicklungsgang der photogrammetrie and über die bisher angeführten hauptsächlichsten photogram-

metrischen arbeiten, p. 202-209. Literatur, 109-211. Kapitel viii. Die aëronautische photographie. 1. Die luftballon-aufnahmen. A Wesen der luftballon-photographie und bisher in diesem gebiete vorgenommene versuche, p. 211-213.—B. Die einrichtungen für di ausführung photographischer aufnahmen vom bemannten aus, p. 213-218.—C. Vorschläge Dr. Stolze's und Meydenbauer's zur lösung des problems des photographie vom gefesselten unbemannten luftballon aus, p. 218-226.—2. Die photographischen aufnahmen mit fliegendem drachen, p. 226-228.—3. Die photographischen aufnahmen mit der raketen-camera, p. 228-229.

60 PORRO, J.

La tachéométrie, ou l'art de lever des plans et de faire les nivellements. . . . Par J. Porro, Officier supérieur du génie en retraite . . . Nouvelle édition, revue et considérablement augmentée . . . Paris, Impr. de Victor Dalmont, 1858.

23 cm. 5 pl.

The first edition was published in 1847.

61 PULRICH, CARL.

Neue stereoskopische methoden und apparate. Berlin, J. Springer, 1912.

62 PULFRICH, CARL.

Stereoskopisches sehen und messen. Jena, G. Fischer, 1911.

40 p., 17 figs. 25 cm.

"Mit Literatur-verzeichniss seit 1900."

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Ueber neuere anwendungen der stereoskopie und über einen hierfür bestimmten stereo-komparator. Mittheilung aus der optischen werkstatt von Carl Zeiss in Jena. Berlin, 1902.

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Fold. plate: Photographic map.

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Contents.—Introduction. i. Principes de métrophotographie. ii. Applications de la métrophotographie. Phototopographie de précision. iii. Applications de la métrophotographie (suite). Phototopographie aérienne. iv. Applications de la métrophotographie (suite). Reconnaissances phototopographiques terrestres. v. Applications de la métrophotographie (suite). Reconnaissances photographiques côtières. vi. Applications de la métrophotographie (suite). Utilisation des documents photographiques quelconques. Application aux levers topographiques, aux levers d'architecture et de machines.

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"Reference works on geodesy": p. 809-810.

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(To be continued.)

GENERAL WILLIAM BUEL FRANKLIN

FROM AN ENGRAVING BY A. H. RITCHIE

CONSTRUCTION OF CONCRETE DAM IN HUDSON RIVER AT TROY, N. Y., 1916.

Report Upon Examination and Tests of Rock Foundation for the Dam.

By

Mr. A. C. Harper,
Assistant Engineer.

The rock beds in this region are much folded, very compact shales geologically known as "Hudson River beds," comprising four distinct deposits (Normans Kill shale, Middle Trenton shale, Cannajoharie shale and Loraine shale). At the site of the dam the "Middle Trenton" shale is found.

A profile of the site together with a trace and sections of the dam are shown by Fig. 1 herewith.

The surface and character of the rock were approximately determined by borings made with jump, hand driven, and calyx drills. Results of the borings indicated a very uneven surface of seamy rock and large boulders. The amount of core obtained by the calyx drilling was, in most instances, so small in comparison with the depth of the hole that it gave little or no definite data as to the strata or structure of the rock. Some of the samples were hard and compact but most of them disintegrated more or less when exposed to the action of air.

About 3,000 square feet of rock, at the site of the shore end of the west arm of the dam, was uncovered and exposed to air for a period of about six weeks; during which time tests were made by forcing air and coloring matter, under 60 pounds pressure, into the rock through a 2-inch drilled hole 14 feet deep, and for resistance to pull, on steel rods cemented into drilled holes. An examination of the surface, for roughness, structure and strata was also made.

The test holes were hand drilled on 10-foot centers and with the exception of the one to which the air tests were applied were from 4 to 6 feet in depth. The drilling of the 14-foot hole indicated no material change in the rock structure after penetrat-

ing the compact surface crust, which is about 3 inches thick. A stream of sulphur water was encountered, at a depth of 10 feet, which rose in a pipe to a height 6½ feet above the surface of the rock and maintained a constant flow. It was piped to a point beyond the downstream face of the foundation.

The compressed-air tests indicated fissures; but an attempt to force discolored water through them was unsuccessful

The tests made by pull on anchor bolts indicated that the rock might safely be depended upon to develop their full strength. The steel bolts used were made of the "Kahn" bar, 1-inch section; they were cemented into 2-inch drilled holes with neat Atlas cement grout. The lower ends of the rods were upset and the upper ends bent and welded, forming a 4-inch eye. The pull was made by a 24-inch by 20-foot I-beam used as a lever; the weight applied being sand in bags weighing 100 pounds each.

Test No. 1—

Depth of hole, 6 feet;
Cement grout, 19 days old.

Slight radical cracks appeared in the surface of the rock with a pull of 35,500 pounds, slightly increasing in size to a width of ⅜ of an inch with a pull of 40,000 pounds when the weld of the bolt eye failed.

Test No. 2—

Depth of hole, 4 feet;
Age of grout, 25 days.

The welded eye of the bolt failed with a pull of 45,500 pounds and the surface of the rock showed one very slight radial crack. The bolt was reshackled and the pull increased to 46,000 pounds at which the bolt itself parted.

Test No. 3—

Depth of hole, 4½ feet;
Grout, 26 days old.

With a pull of 72,000 pounds the pulling rig failed. The bolt showed slight elongation but no cracks appeared in the surface of the rock.

The surface cracks in test No. 1 were very likely due to the failure of the cement grout.

The uneven and jagged surface and the structure of the rock.

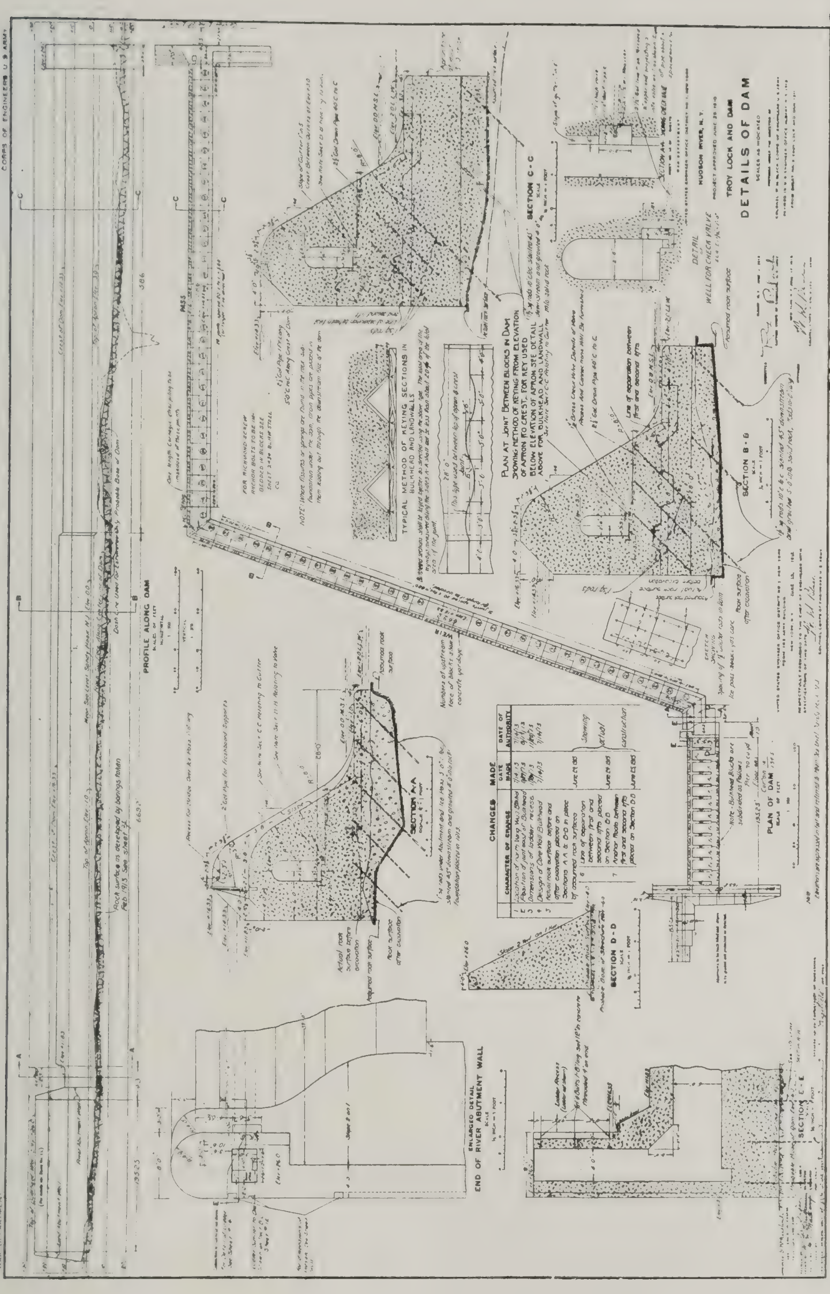

WAR DEPARTMENT
CORPS OF ENGINEERS U.S. ARMY
PROFILE ALONG DAM
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
PLAN OF DAM
CHANGES MADE
TYPICAL METHOD OF KEYING SECTIONS IN BULKHEAD AND LANDWALLS
PLAN AT JOINT BETWEEN BLOCKS IN DAM
ENLARGED DETAIL END OF RIVER ABUTMENT WALL
DETAIL WELL FOR CHECK VALVE
HUDSON RIVER, N.Y.
TROY LOCK AND DAM
DETAILS OF DAM

Fig. 1.

the tilted strata (10 to 60 degrees from horizontal) and the angle between the axis of the rock folds and that of the dam are such as to render unnecessary any great expense for channeling or the use of anchor bolts or steel dowels. The difference in elevation between the highest and lowest point in the area examined was about 4 feet and a variation of about ½ foot, generally obtained within an area 4 feet by 4 feet (16 square feet). However, in order to secure additional stability and subject to variations due to local conditions in the underlying rock, 1½-inch bars, set 4 feet into the rock and spaced 10 feet apart, have been used.

The surface rock generally is very compact; but it soon disintegrates when exposed to air; however, local engineers regard "Hudson River shale" as affording a satisfactory foundation for heavy structures, especially when it is not exposed to air. The foregoing applies to the area (3,000 square feet) at the west end of the dam where the tests were made. During the progress of the construction, it was noticed that the rock surface became more water worn and smooth as the axis of the main channel was approached.

From the foregoing it is established that the foundation of the dam is amply stable in character and strength. The base of the concrete dam lies in general below the surface of the overlying material constituting the river bottom, a distance varying from 2 to 15 feet. The depth of overlying material along the east arm is considerably more than that along the west arm. With a view to securing the best practicable bond between the concrete dam and the foundation rock, the surface of rock after exposure was thoroughly cleaned with water and wire brushes. The surface rock was then covered with a thin layer of rich mortar, after which the concrete was deposited in place.

Comments on Rock Foundation for Concrete Dam.

By

Maj. M. J. McDonough, C. of E., and Mr. D. A. Watt, Asst. Engr.

The general appearance of Hudson River shale does not, as a rule, produce a favorable impression on any engineer who examines it for a foundation. When exposed to the weather, it is usually friable, and more or less disintegrated as far as frost can penetrate.

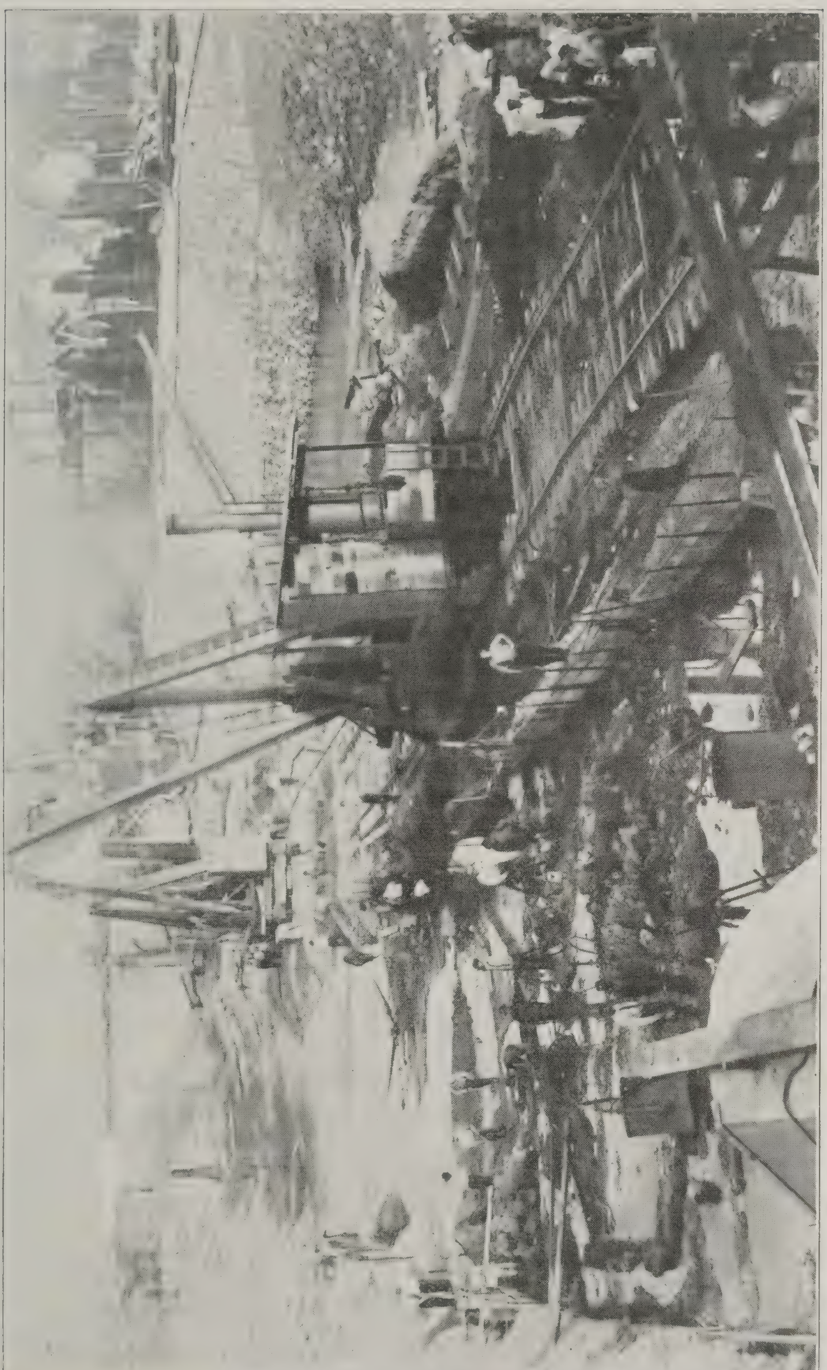


Fig. 2.

However, where it is protected from the air, it seems to last indefinitely without further deterioration. For instance, an example recently came to light in this locality where broken shale had been used for padding the interior of a canal bank some 50 years ago, but when the excavation uncovered it, it was found to be in perfect condition. A year later, however, it had been completely disintegrated by the weather. Another example may be quoted where similar pieces had been used in the concrete wall of a power house bulkhead built some fifteen years ago. In many cases the shale was within an inch of the face of the concrete, but, as in the other example, it was found when uncovered to be in perfect condition, although it shortly went to pieces under the effect of the weather.

In the gravel used for the concrete capping of the dikes in this vicinity occasional lumps of shale were found and became incorporated in the concrete. Where exposed on the surface, they usually go to pieces after a year's exposure, leaving small cavities, but where protected under a film of concrete, the strength of the latter appears sufficient to prevent deterioration. On the other hand, the sand used for the aggregate is full of small particles of shale of about the size of the accompanying grains of sand, but the weather does not appear to affect these in any way. However, as shown by the tests made on samples of the mortar in which this shaly sand has been used, the general strength is not equal to that of the better grades of sand, and the compressive strength does not appear to exceed 1,000 pounds to the square inch.

As stated in the foregoing article, the character of the rock under the lock and dam showed the same general features as are usually met with in the Hudson River shale. Soft seams which could easily be removed with a pick were met with alongside of seams which required to be blasted, and occasional seams of hard, black igneous rock varying from a few inches to a foot or two in thickness were found intruded in the shale. The high portions of the rock foundation showed more characteristics of this nature than where the rock lay at a considerable depth below the river bed, although occasional soft areas were met with throughout the entire work.

A curious cavity was uncovered in the rock near the center of the river, consisting of an irregular elongated hole which extended to about 50 feet below the water level, or about 30 feet below the surface of the adjoining rock. The sides were smooth and polished and almost vertical, and the hole was filled for about 20 feet from

Fig. 3.

the bottom with coarse sand and some gravel, over which lay a blanket of gravel and boulders. The excavation did not disclose any apparent reason for the existence of the cavity, since it was not shaped like a pot hole and extended up and down stream as shown by borings for not over about 30 feet each way.

Report on Methods of Keying Blocks.[1]

By

Mr. Frank P. Fifer,

Junior Engineer.

The type of vertical keys used between sections in the bulkhead and abutments of the dam at Troy consisted of V-shaped grooves, similar to those described for the lock walls.

This V type of key was also used in the monoliths of the dam proper for that part of the structure below the elevation of the apron, in addition to which the up and down stream halves of each section were set at an angle to each other, thus making a V-shaped joint of the whole face. For that part of the dam from the elevation of the apron to the crest, a key consisting of a series of waves or curves was adopted. A plan view of this type of joint, together with a typical section of the west arm of the dam, is shown in Fig. 4. The east arm section is similar in outline, the crest being 2 feet lower in elevation, and similar joints were used in it.

The curve type of joint secures a maximum effectiveness with a minimum cost in construction. Any other joint employing projections of the V-type or otherwise, would require for the same effectiveness a very large number of pieces, requiring much handling in placing and removing them at each joint, besides entailing some breakage. The bonding shown being integral with the form itself avoids this extra work, and is ready for use as soon as the form is secured.

The sections of the dam were placed in two lifts. The first lift extended from the prepared rock surface to the top of the apron, as shown in Fig. 5. This foundation course was anchored to the rock surface by 1½-inch square rods, 10 feet long, slanting downstream at an angle of 45°, spaced 10 feet on centers, and are

[1]Revised by Maj. M. J. McDonough, Corps of Engineers, U. S. A., and Mr. D. A. Watt, Assistant Engineer.

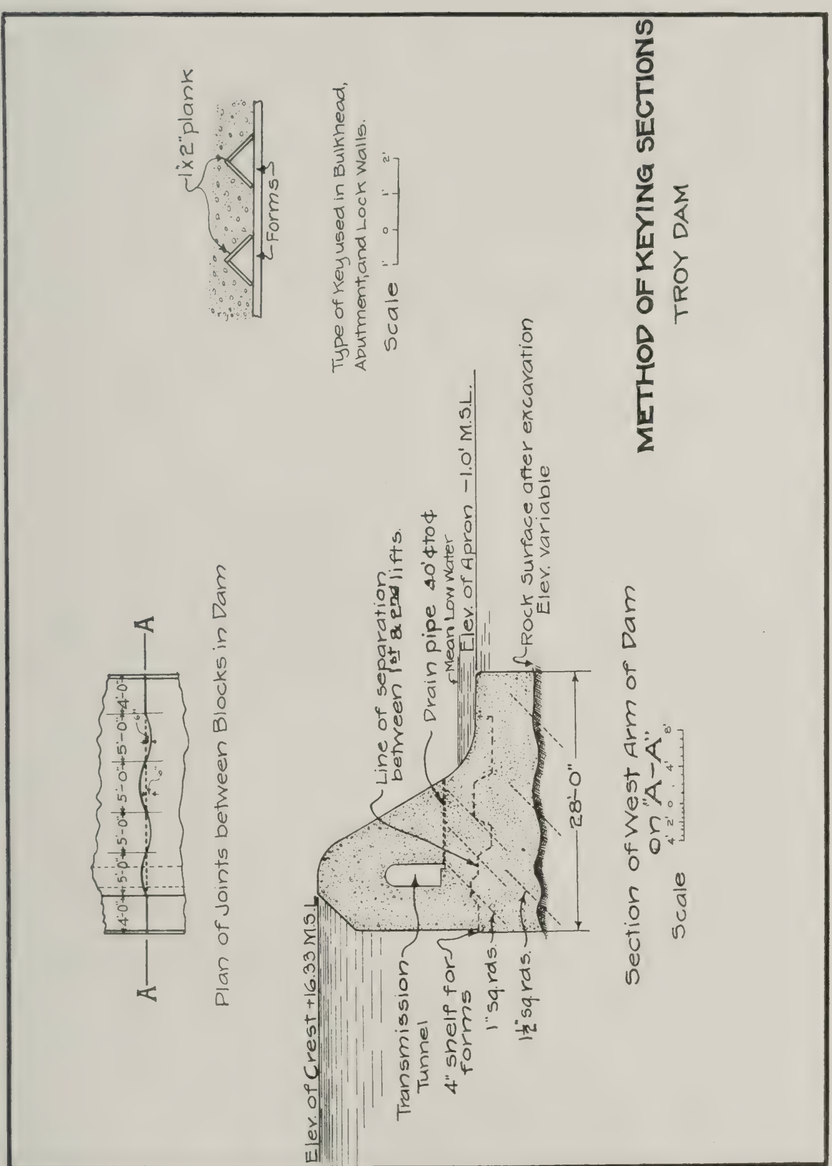

METHOD OF KEYING SECTIONS
TROY DAM
Plan of Joints between Blocks in Dam
A
A
4'-0"
5'-0"
5'-0"
5'-0"
5'-0"
4'-0"
1"x2" plank
Forms
Type of Key used in Bulkhead, Abutment, and Lock Walls.
Scale
Section of West Arm of Dam on "A-A"
Scale
Elev. of Crest +16.33 M.S.L.
Transmission Tunnel
4" shelf for forms
1" sq. rds.
1½" sq. rds.
Line of separation between 1st & 2nd lifts.
Drain pipe 40' c to c
Mean Low Water
Elev. of Apron -1.0' M.S.L.
Rock Surface after excavation Elev. variable
28'-0"

Fig. 4.

grouted about 5 feet into solid rock. The second lift extends from the top of the apron to the crest of the dam. The bond between these two lifts is secured by making the line of separation between the two lifts a series of knobs and depressions, as shown. In addition to this bonding, 1-inch square rods were placed on a 45° downstream slant, as shown, the ends of the rods being embedded to an equal depth in each lift. These rods are spaced about 8 feet on centers, and are about 8 feet long; they were simply stuck into the green concrete of the foundation.

Report on Steel *vs.* Wooden Forms.

By

Mr. John J. McCabe,
Junior Engineer.

The steel forms used on the work at Troy were made up of panels, 2 feet high and 3, 4, 5 and 6 feet long, constructed of ⅛-inch plates riveted to horizontal angles, and reinforced at the ends where staples were provided for fastening the panels to upright angles from 4 to 10 feet long. The uprights were bolted together to make a unit face form. The details of a typical section of steel form are shown in Fig. 6. For the curved face and bulkheads of the dam forms, special plates and angles were provided, as shown in illustration of steel forms for the dam, assembled (Fig. 7).

There were two complete sets of steel forms covering two 20-foot blocks, rented for construction of the dam; but as work on the east arm was started very late in the season, and it was realized that two forms alone would not allow placing of concrete to be carried on uninterruptedly enough to complete the arm before close of the season, additional units were made up of wood.

These wood forms covered the section of the dam above the apron only, concrete in the base being poured ahead as the excavation progressed with the use of steel forms, lumber, or both, as found desirable. The forms for the upper part were placed from apron to crest in one set-up, and the concrete poured the height of the form usually in one lift. No extra wood forms were made for the up stream face of this upper section, since steel panels from the lock form contract were available and were used. Comparison

of the cost of steel and wood forms is made between parts that were used in both steel and wood, viz, down stream face, curved bulkheads, crest slope and tunnel.

With 2-inch tongued-and-grooved dressed spruce plank at about $33 per thousand feet B.M., waling timbers at $30 per thousand feet B.M., and 2-inch rough plank at $28 per thousand feet B.M., the cost of the two standard wood forms, material and labor, built in complete panels for each of the faces, bulkheads, top

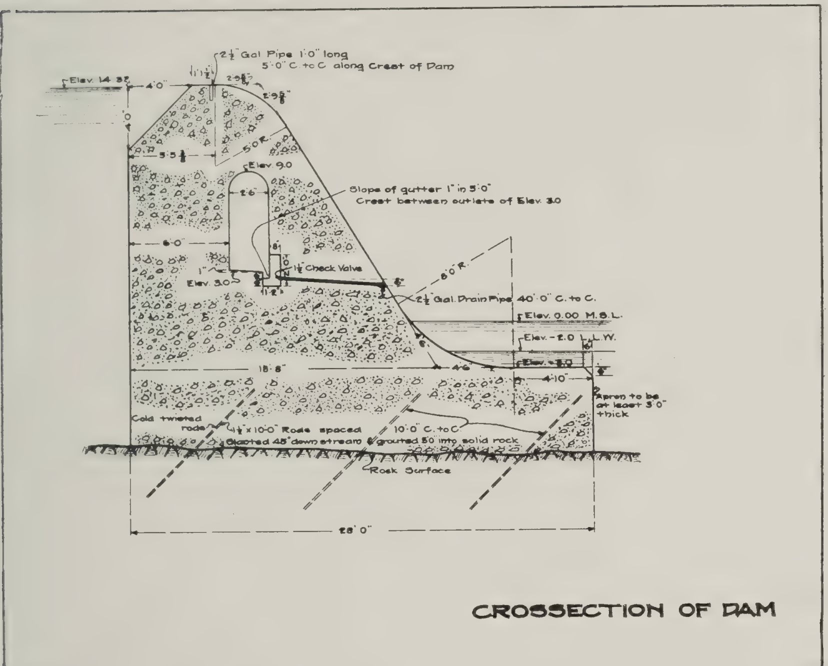


Fig. 5.

slopes and tunnels, ready to be set up, was approximately one-eighth of the contract rental price and cost of first assembling of steel forms for the corresponding parts.

In erecting the same labor was used on steel and wood forms, carpenters following up placing expansion strips, tunnel drains, etc., so that cost of erecting was the same for either kind of forms. If the steel forms alone had been used, the absolute cost per cubic yard of concrete for form erecting would, of course, have been reduced one-half; but this would apply also to the wood forms, for they were in good condition at the completion of the work and

could as well have been used alone. There were sixty-two 20-foot blocks in the dam, which would necessitate using each of the two wood units thirty-one times; but as the faces, bulkheads, crest slope and tunnel were each built in a complete unit with bolted joints, being moved by a crane and requiring no stripping of planking, etc., it is believed the wood forms would have survived the service. Actually, the closures between alternate blocks were made with additional wood forms, consisting of the curved back, crest slope and tunnel, made 2 feet longer than the blocks to allow for lapping on the concrete of the completed blocks. Allowing for the use of these closure forms to conserve the life of the two standard wood units, the latter would be used not over twenty times each, which is not excessive. If the first cost of these closure forms be added to that of the two complete units, the first cost of the wood forms covering four blocks would still be only about one-fifth of that for the steel forms covering two blocks.

From the above, it appears that owing to the high rental cost, steel forms are economical only where they can be used over a large number of times, so that the rental charge will amount to less than the cost of labor and material for making enough wood forms to last the job. However, when a number of wood forms, sufficient to last the job are made, there is the advantage of having a larger number of form units available.

The above comparison holds if the forms are handled as they were at Troy, using a crane for erecting and shifting each face or bulkhead in a complete unit; for the labor was identical for handling either type of form. Where a crane or derrick is not available and the forms are handled by hand, necessitating complete stripping before moving ahead, it is doubtful if the cost would be so favorable for the wood forms. The steel forms may be knocked apart and set up again in place by common labor, where the wood forms would require carpenters and, in addition, the life of the wood forms would be considerably shortened.

Although it is stated above that erection cost was the same for either type of form, this was not so at the commencement of the work on the west arm of the dam. At that time, carpenters and their helpers erected the wood forms when in use and a non-skilled labor gang erected the steel forms. A separate account of cost kept on the two kinds of forms at that time showed the cost of erection of wood forms to be about 80 per cent of that of steel. A change in the organization for form work was made, including in

the gang a better class of labor and men familiar with rigging. This gang erected and shifted *all* forms and were followed by a small carpenter gang that drew the faces to accurate and final line and placed the drains, strips, etc. The carpentry work was required equally on the steel and wood forms. This organization

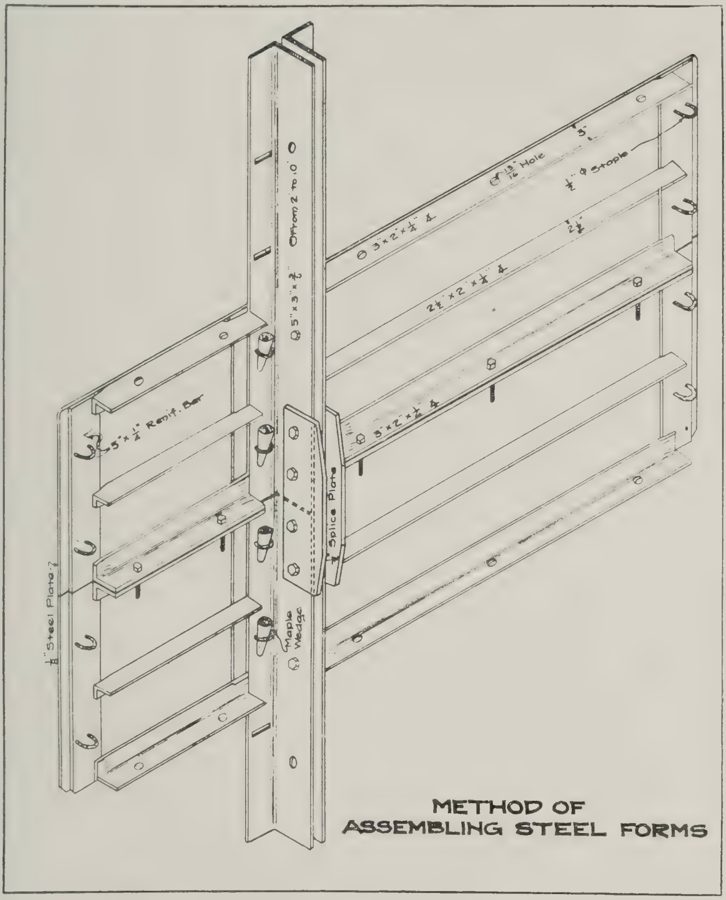


Fig. 6.

showed a reduction in cost of form placing and approximately equalized the charges on the two types of forms. It should be remarked here, however, that the steel form erection is costlier than wood in a wall that is not strictly uniform in cross-section. This was marked in the work on the lock walls where changes in the outline of the walls necessitated filling out with wood where steel

forms were being used. Because of the difficulty in connecting the wood to the steel plates, it is hardly possible to obtain a neat result and, in addition, the work so done is slow with corresponding high cost. One of the simpler cases of this kind met with at Troy is in a block having a radius edge at one corner. If wood face forms are used, this radius form may be a light one of wood, or tin and wood, and held in place by nailing frequently along its edges, with small finishing nails to the wood face forms. Where steel forms are used, the radius form must be fastened with bolts run through holes punched in the steel plates, and, since these bolts cannot be closely spaced or placed at the edge but fastened through the ribs of the radius form, an open joint will very likely be found with the resultant scab in the finished work from mortar running behind the radius form at its edges. In a more complicated form, such as a curved nose on the end of a pier or wall with a batter face or a rounded horizontal edge running into a rounded vertical edge, etc., it is almost impossible to obtain neat results because of the difficulty of making connection to the steel plates.

In the work on the dam the above objection was not serious, since the cross-section of the dam was uniform throughout, but on the lock walls which included frequent changes in cross-section, often in the same block, this matter of filling out the steel forms was unsatisfactory and slow and undoubtedly would show increased cost over similar all-wood form work had there been such available for comparison.

The difficulty of connecting wood to steel forms is also met with in walls requiring interior forms for recesses, valve wells, castings, etc. Nailing strips, spacers, etc., cannot be placed in the steel forms without punching the plates, and if this is not done, and at times even in addition to punching plates, it is necessary to suspend the interior forms from timbers spanning the top of the face forms. These timbers, where the walls are wide, are necessarily heavy, and if many are used obstruct the placing of concrete and delay it accordingly.

The steel forms, with their large number of vertical and horizontal joints, fastened with wedges and bolts, are more troublesome to line up because of the yielding of the plates at the joints. This occurs after the forms have been handled a few times and the distortion finally is so marked it is necessary to knock the forms apart and reassemble. This applies to face forms and not to tunnel and culvert forms. As a result of this yielding at the

joints, the face of the finished concrete will not show a smooth plane surface but one which varies between plate areas; and, in addition, will show offsets and wide joint lines with the accompanying "fins" which are unsightly enough at times to require rubbing.

An inspection of the concrete at Troy showed an excessive amount of "sand showers" on the faces where steel forms were used. These are areas over the face showing irregular or fan-shaped groups of sandy streaks, totally free of cement, and are undoubtedly due to the slick surface of the steel allowing excess water in the concrete to work upward at the face, washing the cement from the mortar which has been puddled to the face.

From experience on the work at Troy, it is concluded the steel forms are not economical or capable of giving neat results on lock and dam work because of the complicated nature of the walls and the large amount of filling out, intricate fitting, etc., necessitates the use of better than unskilled labor excepting perhaps for the first assembling of plates into units. The first cost of rental and the increased cost of erecting on such work can not be offset by increased length of life of steel forms over wood and use of cheap labor, excepting where the steel forms may be used a great number of times as outlined in the first part of this article and where the work consists of uniform walls or work that requires no auxiliary forming of wood.

Comments on Steel *vs.* Wooden Forms.

By

Maj. M. J. McDonough, C. of E., and Mr. D. A. Watt, Assistant Engineer.

The first cost of the Blaw patented forms was 4½ cents per pound of steel; the resale of the used forms to the steel contractor reduces the price, approximately 4½ to 3¼ cents per pound. Thus the first cost of the forms on a scale basis is 4½ cents per pound, while on a rental basis it is 3¼ cents per pound. This figure is very greatly in excess of the corresponding figure for the cost of wood forms.

The especial attributes of steel forms are represented as being, first, a saving of the item of labor cost of erection and, second, longer life. It is claimed that they can be used a much greater number of times than corresponding wood forms can be used. To effect these two savings, therefore, it is necessary that concrete shall be of a lineal or regularly recurring type, what is usually

called straight-away work. Examples of this character of work are tunnels, culverts, retaining walls, etc. If the concrete is other than lineal in character, if it has especial or unsymmetrical features calling for interior forms within the steel forms or additional to them, the patented steel forms, instead of showing a saving in the item of labor cost of erection, will actually show no saving but a deficit over the use of wood. Again, if the total employment of the forms does not exceed the life of good timber forms, the extra first cost of the steel cannot be absorbed. In general, therefore, steel forms will be more expensive than timber forms where the work is not regular and uniform in character and where the amount of it is not greater than can be served by a single set of wood forms.

The life of wood forms is usually controlled not by actual breakages of the timber but by scarring or roughing of the plank against which the concrete lies. After a wood form has been used once, it is necessary to free the plank from adhering particles of mortar in order to obtain a smooth face, but this work is also necessary with the steel forms. The main timbers or bracing of a wooden form can be used practically throughout the life of any job without the necessity of renewal, and where the face plank has become too rough or too much broken along the joints to secure a good face, it is believed that it would be practicable to nail over the scarred faced plank a new lining of thinner plank which would be comparatively inexpensive and could be ripped off and renewed should the continued use of the form demand this. With such an arrangement, it is believed that the life of the wooden form could be made practically as long as that of the steel form.

Report on Sand Streaks in Concrete.[1]

By

Mr. D. A. Watt,

Assistant Engineer.

It has probably been noticed by most engineers who have been connected with the building of concrete structures that there is a tendency for sand streaks to appear upon the face of the finished work, and that these appear to be more prevalent where the concrete is very wet than where it is of a moderately dry mixture. This peculiarity was noticed on the work at Troy, where steel forms were used for a considerable portion of the structures. It

[1]Revised by Major M. J. McDonough, Corps of Engineers.

Fig. 7.

was noticed also that the streaks were much more common where the steel forms were used than where the forms were of wood. Inquiry was made of several engineers and superintendents as to what was the probable cause of the disfigurement, and in all cases the answer was that they believed it to be due to the excess of water in the concrete working its way to the face of the form and then percolating downward, thus carrying the cement away from the face. This belief, however, did not seem to be borne out by a close examination of the work at Troy, since there was no deposit of cement at the lower end of the streaks, such as must have been the case if the foregoing theory were correct. There being no possibility for the cement to escape outside of the form it would necessarily have collected at the bottom of the streak or along the sides, and have shown itself distinctly. This was not found to be the case, and no trace of collected cement could be found anywhere along the streak. Moreover, the streaks were usually much wider at the top than at the bottom, whereas it seemed probable that water percolating downward would tend to spread out as it found its way down the form.

The puzzle was solved by one of the concrete foremen whose attention had been directed to the matter, and who discovered that the water, instead of percolating downward, percolated upwards, and carried the cement with it. The process was not confined to the face of the forms but appeared at various points in the mass of the concrete, and was apparently due to the weight of the concrete gradually forcing out the excess water, and the latter naturally followed the easiest path of escape, which was upwards. The escape of the water was through very small fissures or holes not larger than a pin head. The flow would continue for a minute or two and when it stopped there would be left upon the surface a small flat cone of cement. This would account for the fact that no cement appears at the bottom or along the sides of such streaks when the forms are removed, since it is all carried up to the surface

As above stated, the process was much more noticeable with steel than with wooden forms, since the former, having a very smooth face, offered practically no resistance to the seepage of water.

SANDBOX INSTRUCTION IN FORTIFICATION, RECONNAISSANCE AND MINOR TACTICS.

AS GIVEN THE EIGHTH ENGINEERS (MOUNTED).

By

Lt. Col. V. L. Peterson,

Corps of Engineers.

FIELD FORTIFICATION INSTRUCTION.

In all fortification instruction work, two of the principal considerations are time and expense, since it is the lack of time and funds that so often render impossible the adequate training of troops. From previous experience in fortification instruction in the vicinity of our camp, it was known that the thorough instruction of the battalion in outdoor fortification work would be exceedingly slow and laborious owing to the nature of the ground, combined with two other difficulties—which were the few men available and the elements incident to the winter. After consideration, it was thought that the best results could be secured by doing the work in sand, which was placed about 2 feet deep in boxes built in a vacant mess-hall. The boxes were 7 by 64 feet, which is considered the minimum size to develop all the details of the various types of work and at the same time employ a considerable number of men.

The following system was followed throughout all this instruction:

(1) One box was assigned to each company, with a lieutenant in charge;

(2) To arouse interest and stimulate the work, competition between companies was encouraged in presenting the most complete trenches, shelters and other designs;

(3) One company commander was designated as senior instructor of all the companies in order to coordinate the instruction;

(4) Attendance was limited to one platoon from each company each day;

(5) A system of grading the men on the work accomplished each day was adopted.

In connection with this work, there was held a school in the

use and care of all the engineer tools as actually used in fortification work in the joints, frames, and sheeting. So, when a man was called upon in the sand-house to do a certain piece of work with an engineer tool, he had had the benefit of previous experience on actual-size specimens and the real use of that which he had acquired in this tool-work school was doubly impressed upon the man when he saw the employment of the various joints and frames in real miniature fortifications. Other practical experience was given the men attending the sand-box work in the actual handling of excavation, the construction of concrete forms, the cutting of steel bars, the construction of drains, and the

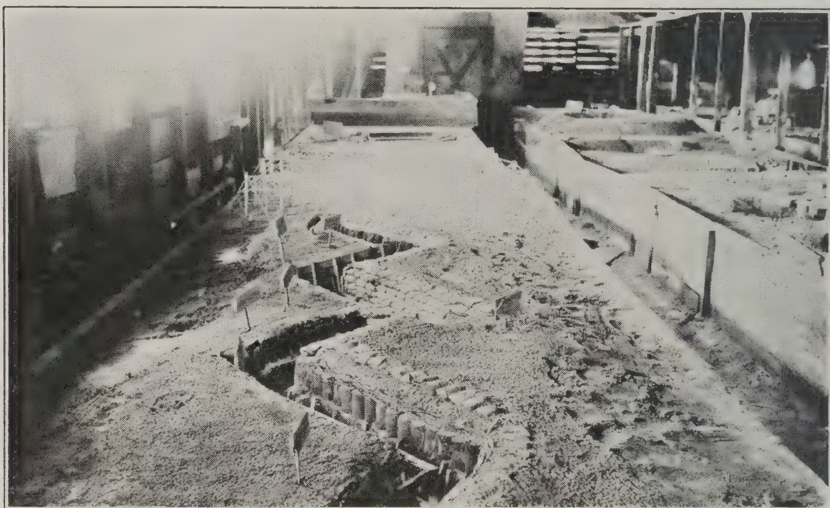


Fig. 1. General View of Sand Boxes. Foreground shows trench with different types of revetment.

mixing and placing of concrete. This experience was obtained as the battalion was engaged in the construction of a large swimming pool at a nearby fort. The details being alternated in this work the benefit was of great value, since fortifications involve all of the above classes of work, as was demonstrated as progress was made in the sand-house. As the men came to the details of the emplacements and shelters, involving concrete work, they had a better understanding of the problems, since they had had somewhat similar experience in the work at the pool.

During the course of instruction the following types of field fortification were built:

(1) Fire trenches of the wet ground and the dry ground types,

Fig. 2. Wire Entanglements. Showing French wire, fence and double apron, low, and high types; section of deep sap in foreground.

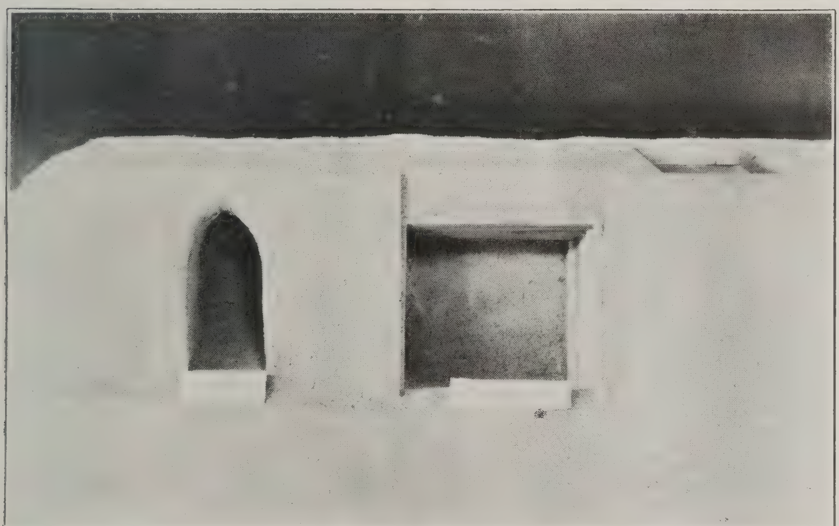


Fig. 3. Russian Sap and Mine Gallery. Showing use of mine-casings in gallery.

using revetments of sandbags, gabions, fascines, plank, concrete, and rabbit wire with canvas and tar paper backing;

(2) Wire entanglements of the high, low, French, the fence and double-apron types, and portable obstacles;

(3) Saps of the deep, ordinary, Russian, and covered types;

(4) Mine shafts and galleries, using mine casing and framing with sheeting;

(5) Machine-gun emplacements of the open, heavy "cut and cover," concrete single wall, and concrete double wall with air space;

(6) Shelters of the "cut and cover" and cave or mined types;

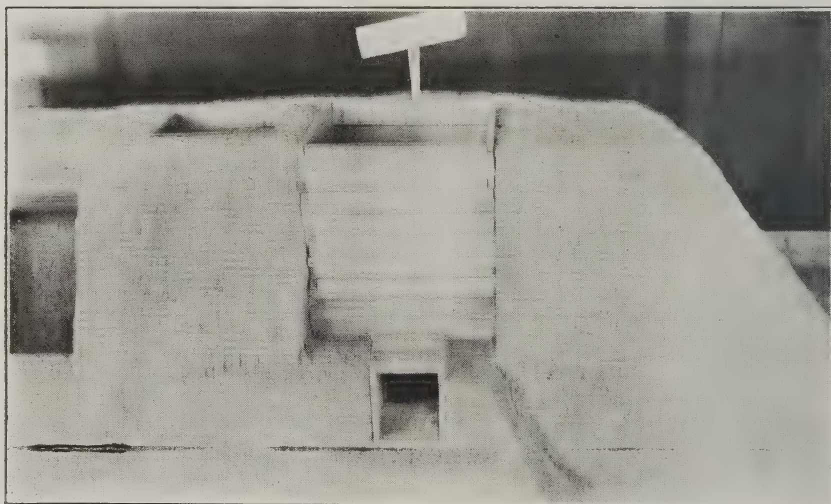


Fig. 4. Shaft and Gallery; using mine casings.

(7) Mine and shell craters, showing the occupation of both lips;

(8) Trench mortar emplacements;

(9) Complete battery emplacements for 75 mm. guns, with shelters for the men and guns and niches for the ammunition;

(10) Forward observing stations for artillery, with protection for the observers.

A scale of $1\frac{1}{2}$ inches to the foot was adopted for the general work and 1 inch to the foot for the large cave shelters. This is considered the proper scale to develop all the details in the small spaces. The measuring sticks were marked in feet and inches corresponding to the scale, which was done so as to impress upon the men the actual dimensions that would be used in actual construction. Sticks of 1 inch cross section were used to represent

Fig. 5. Section of Mine Gallery. Showing use of frames and sheeting.

Fig. 6. Shaft and Gallery. Showing use of frames and sheeting.

the heavy timbers and ordinary lath to represent the heavy planking. Steel rails were represented by pipes and rods, barbed wire by cords, and sandbags by tobacco sacks. Gabions, hurdles, and fascines were constructed from small twigs. Methods employed in construction were those laid down in the "Field Manual" and the pamphlets upon these subjects, except at times a variation was unavoidable, owing to the impossibility of constructing certain details on the small scale. In such cases a full explanation of the correct methods was given.

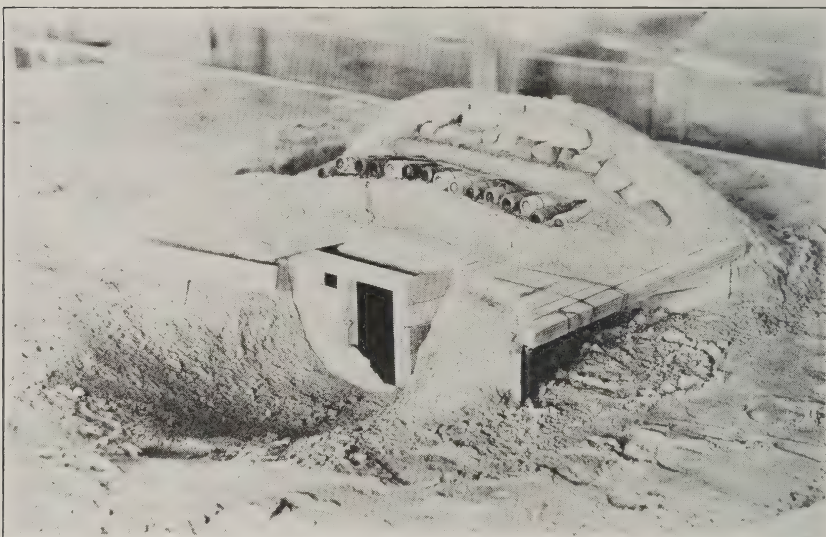


Fig. 7. Machine Gun Emplacement. Cut and cover roof. Cover: 6 inches earth, 18 inches rock, 12 inches earth, steel rails, 18 inches earth, heavy timber.

TRENCHES.

Since the firing trench is the fundamental and basic element upon which complete trench systems are dependent, it was with this subject that instruction of fortifications was started. The dry ground and wet ground types of firing trench were constructed and both were revetted with the common forms of revetment, as shown in the accompanying illustration (Fig. 1). Instruction was given in tracing and digging trenches of the traversed, the "dog-leg," the tenaille, the sinuous, the indented, and the bastion types. Firm anchoring of revetment posts by wire to pickets in front of the parapet and in the rear of the parados was

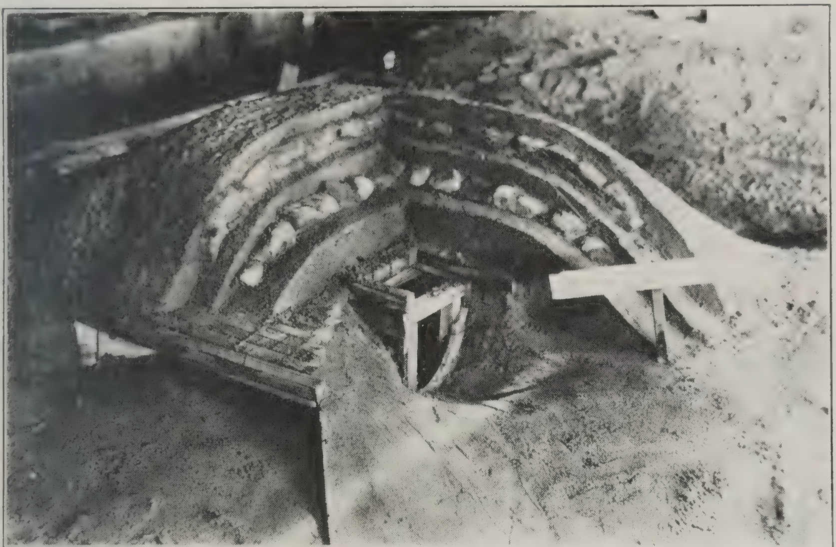


Fig. 8. Machine Gun Emplacement. Cut and cover roof. Cover: 6 inches earth, sacks of cement dipped in water and hardened, double layer, 12 inches earth, 18 inches rock, 2 feet earth, heavy timber.

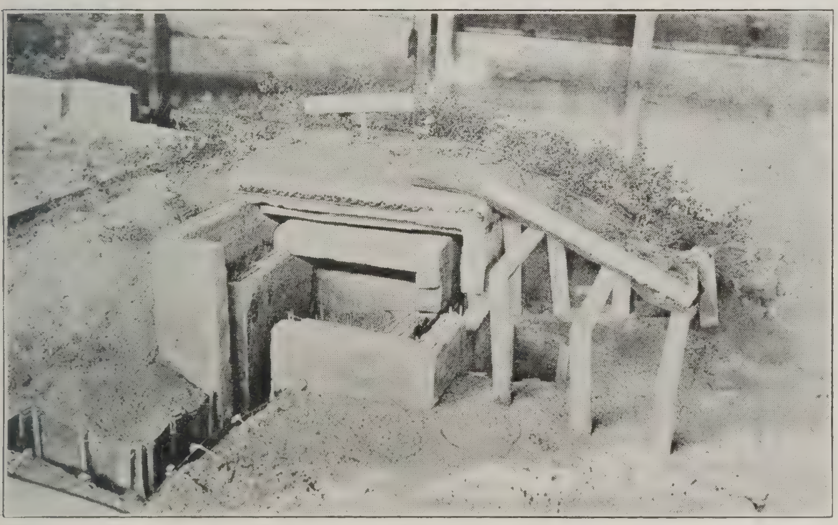


Fig. 9. Machine Gun Emplacement. Reinforced concrete double walls, roof, and air space.

required, owing to the importance of this in actual trench work. In connection with the firing trench, communicating trenches of the wet and the dry ground types were constructed.

BARBED-WIRE ENTANGLEMENTS.

Actual construction of barbed-wire entanglements was supplemented by talks and drawings which covered the importance of wire entanglements, stress being laid upon the location of wire with reference to trenches, the necessity for systematic construction, and the silence required of working parties. Owing to the small scale it was necessary to change the size and organization

Fig. 10. Heavy Machine Gun Emplacement. Reinforced concrete, for two guns.

of the working parties, but the men were drilled in this work so as to get an unmistakable idea of the organization and the duties required of the members of the party actually engaged in constructing wire entanglements. The portable obstacles built were the hedge-hog, the knife-rest, the Brum spiral and the "Chevaux de Frises." (Fig. 2.)

SAPS.

The type of saps constructed were the ordinary, the deep, the covered, and the Russian. In this work particular attention was required in preventing the men from constructing a sap as if it were a trench. Again, owing to the small scale of this work, there was a tendency not to carry forward the saps exactly as

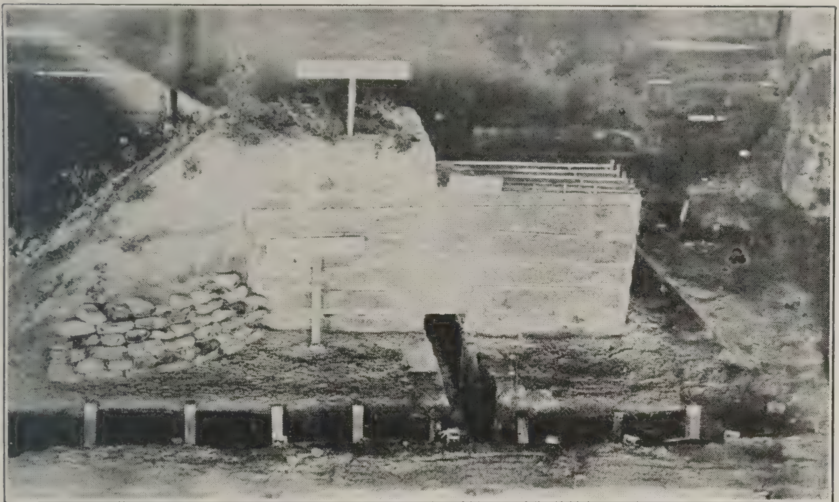


Fig. 11. Heavy Machine Gun Emplacement. (Shown in Fig. 10.)

Fig. 12. Heavy Machine Gun Shelter. Concrete and reinforced concrete—two stories. (See plates, pp. 88-89, "Notes on Field Fortifications," W. D. Doc. 616.)

would be done in real work, but this was soon eliminated by diligence on the part of the instructors. Fig. 3 shows the construction of the Russian sap.

MINE SHAFTS AND GALLERIES.

Mine shafts and galleries were driven by both the casing method and the method with frames and sheeting. The benefit that the men derived from the instruction in the use of engineer tools in joining and framing was plainly noticeable in this work. Each man was required to sink a shaft and drive out a gallery, using

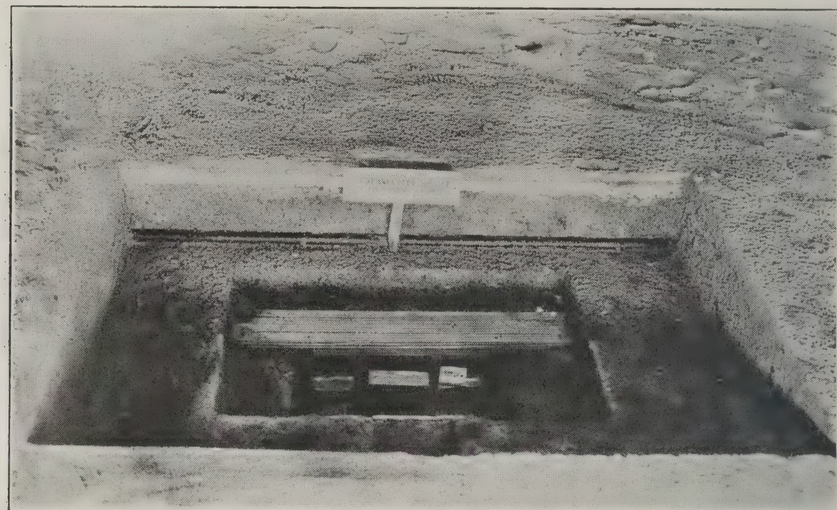


Fig. 13. Cut and Cover Shelter. Cover: 6 inches earth, 8 inches concrete, 2 feet earth, steel rails, 18 inches earth, heavy squared timbers.

both the above methods. Illustrations of these shafts and galleries as constructed are shown in Figs. 4, 5, and 6.

MACHINE GUN EMPLACEMENTS.

The different types of machine gun emplacements constructed included the open, the heavy "cut and cover," the concrete, and the reinforced concrete. These emplacements are shown in Figs. 7 to 12, inclusive.

DEEP SHELTERS.

In all the deep shelter work especial stress was laid upon the proper construction of the joints of caps and stanchions, which work was done according to the standards of the "Field Manual."

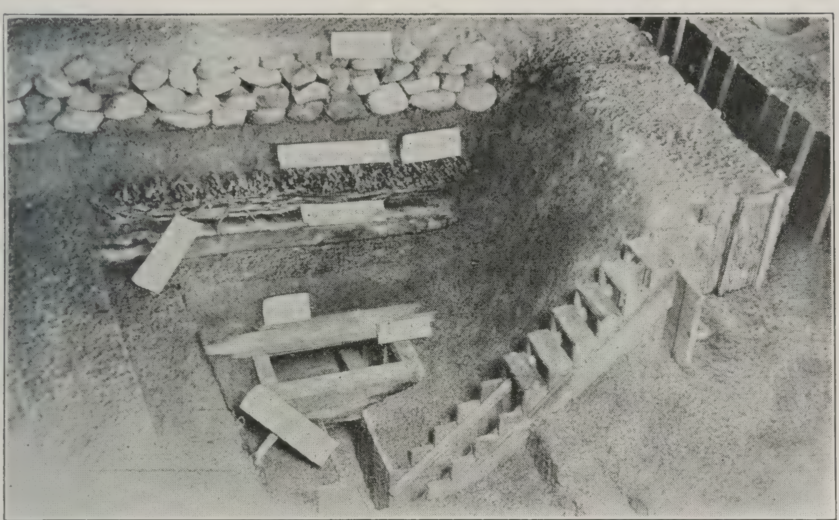


Fig. 14. Cut and Cover Shelter. German sandwich roof. Cover: 6 inches earth, 2 feet rock, 18 inches earth, double layer fascines, steel rails, 2 feet earth, heavy timber.

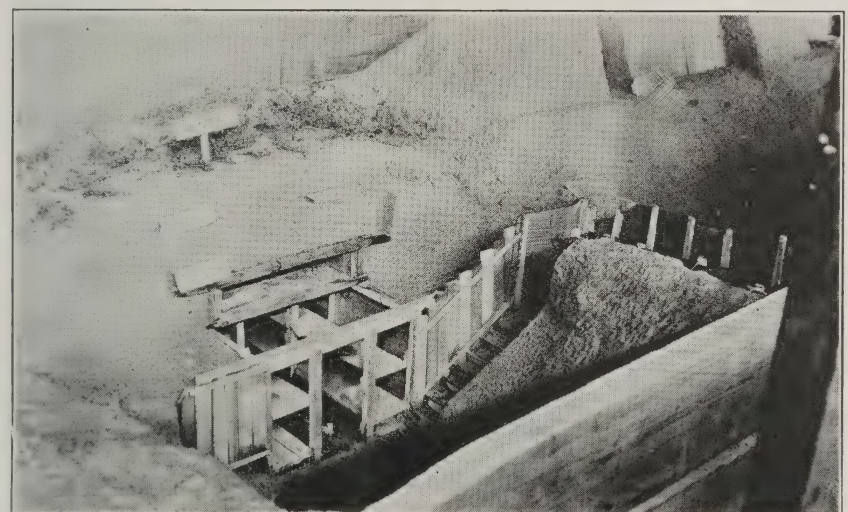


Fig. 15. Cut and Cover Shelter. Air space construction. Cover: 6 inches earth, 2 feet concrete, corrugated iron, steel rails, 15 inches air space, heavy square timber.

the various materials used in the bursting courses were concrete, sacks of cement, rock, rails, and logs wired together. The thickness of each type of material used to resist the various sizes of shells was thoroughly drilled into each working party, as was also the necessity of having the layers so overlap as to resist a shell striking the roof at a maximum angle of 45 degrees with

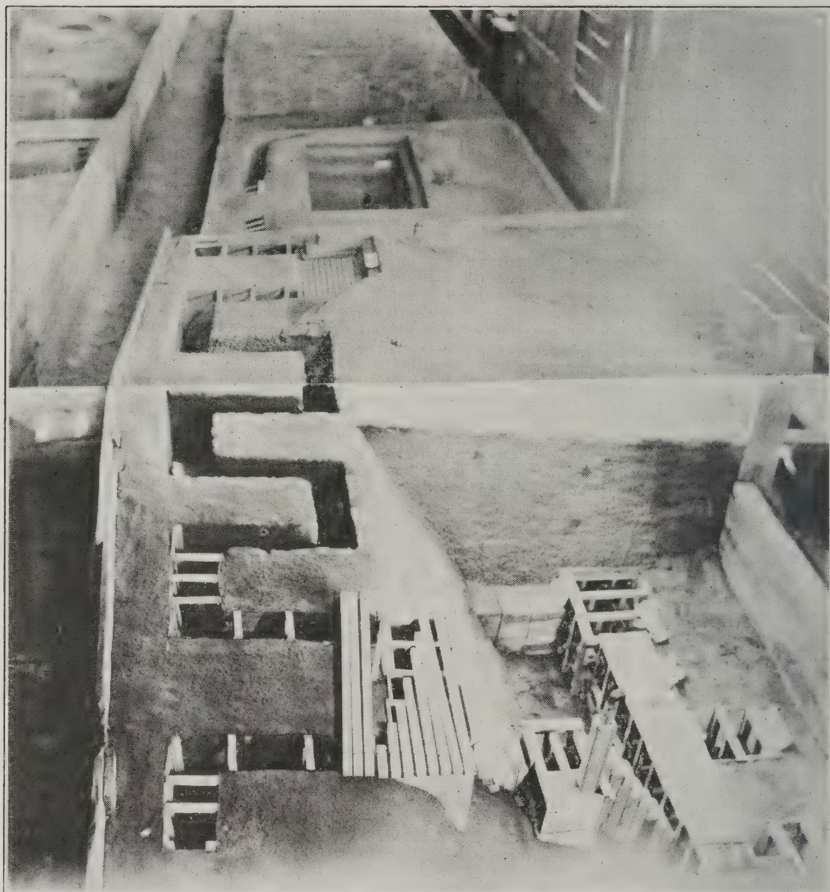


Fig. 16. Cave Shelter (foreground section left open for illustration of construction). Shows details of construction and protection of entrances. (See plate following p. 32, "Notes on Construction of Deep Gallery Shelters," W. D. Doc. 691.)

the horizontal. The construction as well as the benefit derived from an air space wall in the shelter was given to the men. At the last of this work the men were impressed with the sizes of the shelters to hold a specified number of men. The shelters as constructed are shown in Figs. 13 to 16, inclusive.

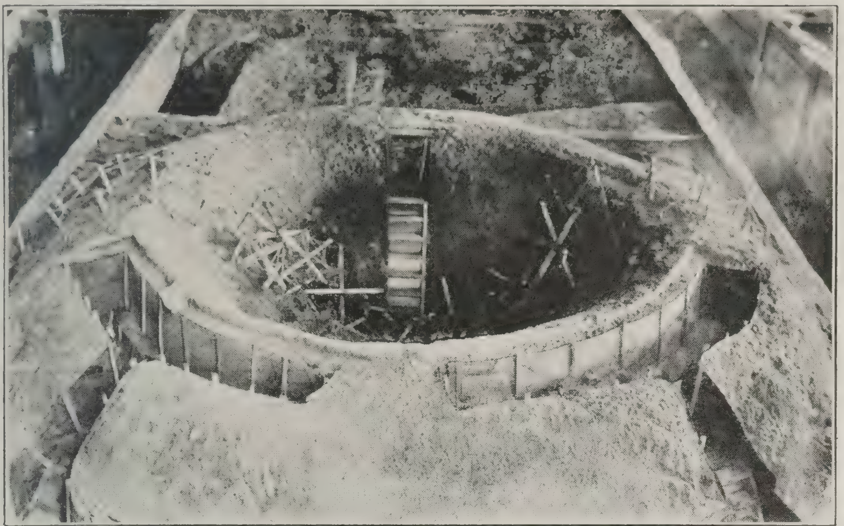


Fig. 17. Mine Crater. Occupation of near lip.

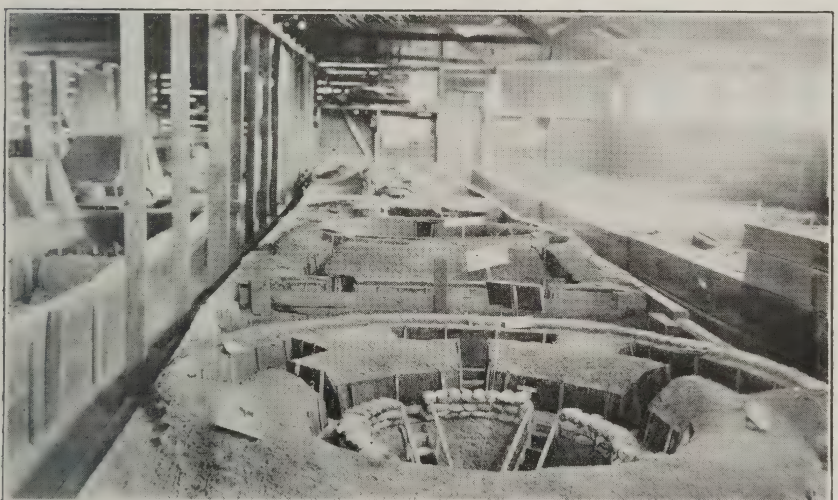


Fig. 18. General View of Sandboxes. Foreground shows occupation of far lip of mine crater.

CRATERS.

The occupation of both mine and shell craters with the accompanying obstacles was developed in detail with complete explanations of the reasons for occupying the far or the near lip. These craters are shown in Figs. 17 and 18.

OBSERVATION POSTS, BATTERY EMPLACEMENTS AND DRESSING STATIONS.

Observation posts for artillery with accompanying shelters for the observers were built with roofs of rail and corrugated iron under a layer of dirt, forming a light bomb-proof shelter. In the type as shown in Fig. 19, the observer looked through a slit be-

Fig. 19. Observing Station (foreground) and Shelter (background). Entrance and steps to shelter left open for observation.

tween two rails. In the cave shelter post there was a cover of 17 feet of undisturbed chalk.

On Fig. 20 is shown part of a battery emplacement for 75 mm. guns, which was completed with accompanying shelters, battery commander station, ammunition niches, and the necessary communicating trenches.

Dressing stations with "cut-and-cover" roof were built as shown in Fig. 21. Inside the shelter are racks for stretchers. A maximum angle of inclination of 30 degrees for the steps and no sharp turns was one of the important details of this work, so as not to prevent the easy passage of stretchers.

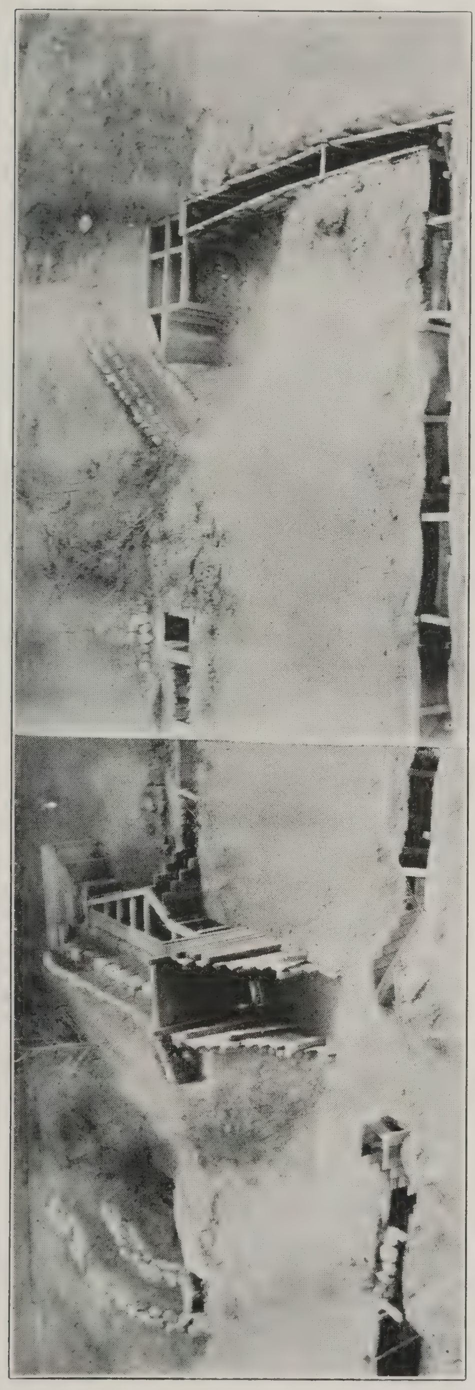


Fig. 20. Section of Battery Emplacement. Showing gun emplacement, circulating trench, entrance to battery commanders station (right), and men's shelter (left).

FINAL REVIEW OF ALL THE WORK.

As a review of this work, models of all the different types of fortifications were built, utilizing all the space in the boxes. All construction was left open in sections, as shown in the accompanying illustrations, to permit of explanation and to allow one to get a mental picture of the different steps in construction.

LECTURES GIVEN ON THE WORK.

The building of these models and the instruction capable of being derived therefrom attracted the attention of the Commanding General of the District, and he directed that a series of lectures on fortifications be given by the Commanding Officer of the Battalion to all the officers of the District. In addition to explaining the models, these lectures were illustrated by means of a print of a battalion supporting point situated on a varied terrain. This print showed the development of a reversed slope, of a wet ground area, and of a forward slope.

The following points were discussed in the lectures:

(1) The engineering duties of line troops in trenches and open warfare;

(2) The siting of trenches, including the advantages and disadvantages of forward and reversed slopes with the conditions under which each should be occupied and the necessity for flank fire and easy communication;

(3) The organization of a wooded area;

(4) Wire entanglements, embracing the necessity of organization and silence of working parties, the advantages of an irregular trace, the proper distance from the firing lines, the time required for construction, and the means of destruction;

(5) The location and use of machine guns, automatic rifles, trench mortars, and 37 mm. guns;

(6) The position of shelters, command posts, storage depots, and strongpoints.

The total attendance at these lectures was about 500 officers, one half of the officers of a regiment attending at a time. More than ordinary interest was displayed, which was evidenced by the fact that many officers returned on Saturdays and Sundays to review the work and quite a few company commanders returned with their non-commissioned officers to give them the benefit of seeing these numerous types of fortifications. Every detail in the location, design, and construction of the types of fortifications as described in this report was explained to these visiting officers. It is believed and hoped that the instruction given these

officers will be more than ordinary help to them as they go along in their work. The interest displayed was taken as an index of the wisdom of the Commanding General in ordering the attendance at this course of lectures.

In connection with this course of lectures, the enormous quantities of material required to give a course of instruction on actual scale similar to the one given in the sand box was shown. An estimate of the amount of material which would have been used in the final exhibition alone, had the various details been constructed full size, is as follows:

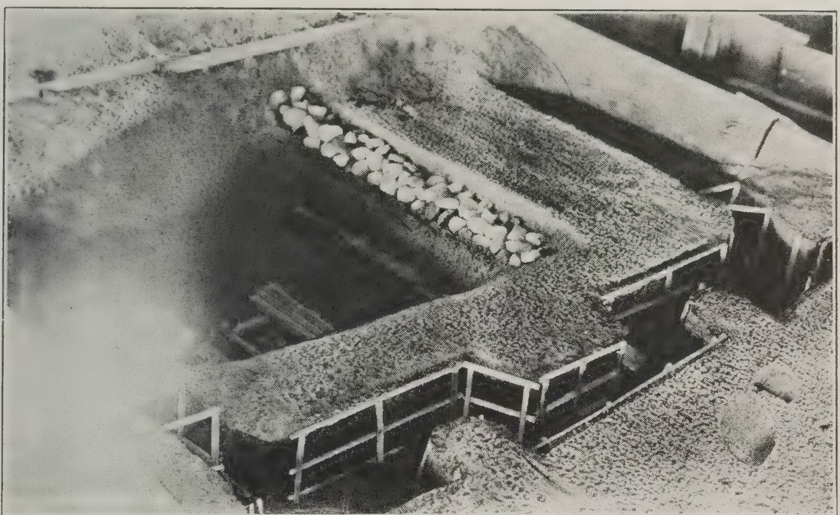


Fig. 21. Dressing Station. ''Cut-and-cover'' roof. Cover: 6″ earth, 18″ rock, 2′ earth; steel rails, 2′ earth, layer heavy timber.

Concrete	cubic yards	670
Timber planking	board feet	100,000
Rails or I-beams	pounds	212,000
Rock, exclusive of the concrete	cubic yards	500
Cement, exclusive of concrete	barrels	100
Logs or heavy timber	linear feet	3,000
Reinforcing steel	pounds	32,000

The cost of this material alone, without considering the time, labor, or transportation, is seen to be enormous. By this construction in the sand, excellent instruction was given, expense was eliminated, time of construction was a minimum, the number of men required was a fraction of that which would be required

for actual outdoor work, weather conditions did not hinder progress, the fatigue of working a hard soil was overcome, and most important of all, each individual was given instruction in every detail of this fortification work. These are the advantages of the plan of the sand-house over instruction by actual work on a true scale in the open country.

BATTALION SUPPORTING POINT.

As soon as time is available, the space between the large sand-boxes will be filled. A battalion supporting point will be traced and dug to suitable scale in this box, giving special attention to the tracing and siting of fire trenches, communicating trenches, strong-points, and obstacles.

SAND BOX FOR SKETCHING INSTRUCTION.

Three sand-boxes, each 7 feet by 10 feet, were used for preliminary instruction for surveying and sketching. The surface of the sand-box was shaped into a terrain suitable for sketching, with the vertical features exaggerated so that the ridges and depressions would stand out sufficiently clear. The principles of contouring were explained to the men, and exercises in tracing form lines on the terrain in the sand were given. Then the sand-boxes were made to represent an actual section of the country, showing clearly every topographical feature, such as the woods, cultivated land, houses, railroads, hills, and streams.

The men were then required to make a complete map of this terrain on a scale of 6 inches to 1 mile, assuming 1 foot on the sand equals a horizontal distance of 1,000 feet and taking one-third of each vertical angle to correct for the exaggerated scale of the layout. Horizontal angles were measured with the prismatic compass, and vertical angles with the slope scale. Excellent results were obtained by this method, as all the men were able after completing the course to take up field work and make maps and sketches quickly and accurately.

USE OF THE SAND BOX FOR INSTRUCTION IN MINOR TACTICS.

For this purpose a sand box was made up as a sketching box. The terrain was varied and made as complete as possible, in order to cover all points that could actually be encountered in real warfare.

The classes were arranged in sections. Problems in patrol, conduct of advance guards, and outposts were studied and dis-

Fig. 22. "The Sandbox used for instruction in reconnaissance and minor tactics."

cussed along the lines similar to those in "Small Problems for Infantry," and "Small Problems for Cavalry."

PATROLS.

The disposition of the members of the patrol and its conduct under the various conditions of a problem were required and, after discussion, the correct solution was explained by the instructor. During the solution of any situation, when messages were necessary, all members of the class were required to write them, in order to give them practice in writing messages.

ADVANCE GUARDS.

Small advance-guard problems were taken up, giving officers and non-commissioned officers different-sized commands and requiring them to dispose of their troops, conduct the advance, and work out the situation. Problems in the conduct of points were solved with a liberal discussion of each solution.

OUTPOSTS.

Outpost problems involving the protection of a small command were solved. The classes were required to issue the necessary orders and to show in the sand-box the disposition and strength —for both day and night—of supports, pickets, sentinels, and the routes of patrols.

The advantages of the sand-box for instruction in minor tactics are as follows:

(1) The great saving of time over map problems, since corrections are made at the time and place of the solutions; this eliminates the excessive work required of a regimental commander in the correction of written solutions of map problems;

(2) All criticism comes at the time of the problem, when the conditions are fresh in the minds of the students;

(3) The conditions are nearer actual ones than is the case when a map is used and the students will therefore absorb details more rapidly;

(4) Previous study is necessary, since all problems must be solved promptly;

(5) A greater variety of problems can be assumed more readily than in the case where maps are used.

RESULTS ACCOMPLISHED.

The energy, interest, and enthusiasm displayed by those actually engaged in the sand-box work, combined with the favorable opinions of many of our officers of rank and experience along with the like opinion of a few foreign officers, served to convince

the Commanding Officer that his original desire was accomplished in that the officers and men of the command were given the most thorough, detailed, and practical instruction in the most interesting manner and in the minimum time. It is earnestly believed that if any man who underwent this instruction is called upon at some future time to assist in the construction of any of the present types of fortifications or to solve any problem of minor tactics consistent with his rank, this man will be able to render more than ordinary service.

OXY-ACETYLENE WELDING.

By

Capt. George B. Malone,

Engineer Reserve Corps.

OXYGEN.

Properties of Oxygen.

Oxygen is invariably the combustion agent used in autogenous welding with the blowpipe. It is useful and even necessary for those using it to be familiar with its properties, manufacture, storage, methods of use, etc. It is, of all bodies, the most widely distributed in nature. It exists in a state of mixture in the air, which contains about one-fifth of its volume of this gas. Water is a compound of oxygen and hydrogen, containing merely 89 per cent of the former element. It is found in nearly all mineral and oxygenic substances. Oxygen was isolated by Priestley in England, and Scheele in Sweden. Lavosier studied its properties, and gave it the name of oxygen.

Physical Properties.

Oxygen is a colorless, tasteless, and odorless gas. Its density is 1.056. One litre at 0° C. and atmospheric pressure weighs 1.43 grams. It is not very soluble in water; 100 volumes of water at 0° C. dissolves a little less than 5 volumes of oxygen at atmospheric pressure.

Formerly, oxygen was considered a body not capable of existing in the liquid state. In 1877, Messrs. Cailletet and Pictet succeeded in liquifying it by compressing it to 320 atmospheres, and lowering its temperature to 140° C. below zero. In the liquid state its density approaches that of water.

Like all other gases, oxygen can be compressed. We will return to that later.

Chemical Properties.

Among chemists, oxygen is known by the symbol O.

Its characteristic property is its power of supporting combustion: a glowing candle will burst into flame if plunged into a jar of oxygen.

Iron heated to redness, burns in oxygen. The combustion is a chemical reaction between the oxygen and the body which burns in it. The product of the combustion is called oxide. In the same category can be placed what are called "slow combustions," which are phenomena of oxidation in which the temperature of the body is not specially high. Oxidation of metals by contact with oxygen (or air, which contains one-fifth) is slow combustion. The intensity of the reaction increases with the increase of temperature; thus, most metals oxidize rapidly when heated to redness in air, and of course much more so in contact with pure oxygen. I shall continually refer to this phenomenon of oxidation, which can be produced very intensely during the process of autogenous welding.

Industrial Manufacture of Oxygen.

Oxygen is usually prepared in the laboratory by heating manganese dioxide to a bright red heat, when it gives up one-third of its oxygen, or, by heating potassium chlorate, which likewise gives up its oxygen. If the potassium chlorate is mixed with about one-eighth its weight of manganese dioxide, the reaction is much more regular.

These processes are not industrial. They were and are even now employed in countries where oxygen could not be obtained in any other way. It is due to the manufacture of oxygen at a low price that autogenous welding is the development, which has stimulated inventors and manufacturers to search for processes, or improvements, which would give oxygen at an advantageous price. In order to obtain it cheaply, one would naturally try to obtain from materials which are free, *i. e.*, air and water, the one containing it in the form of a mixture, the other in a state of combination. Processes for obtaining it by chemical means are reserved for cases where it has to be prepared at the place of consumption (colonies, placed a long distance from industrial centers, etc.).

Manufacture by Electrolysis of Water.

Water is a compound of hydrogen and oxygen. It can be split up into its elements and the two gases can be collected separately. This operation is easily carried out by electricity, and is called electrolysis. Water, to which a small quantity of sulphuric acid or potash has been added is treated with an electric current, in an apparatus called an electrolyser. The oxygen is

liberated at the negative pole, and the hydrogen at the positive pole. The gases are then separately collected, and conveyed to gasometers. The hydrogen is used for oxy-hydrogen welding, filling balloons or other purposes.

Oxygen made by this process is generally very pure. But the electrolysers require a great amount of care and supervision, especially to avoid mixtures of the two gases, such mixtures being extremely dangerous. This risk has been largely diminished in recent years by the use of automatic indicators, which give an alarm in case of diffusion of the oxygen and hydrogen. The process is considered more costly than that of extracting the oxygen from the air, but according to the scale of production, and the general conditions of working, it may compete with them.

Extraction of Oxygen from the Air.

Attempts were made long ago to extract oxygen from the air, where it exists as a simple mixture with nitrogen (nitrogen, 79 per cent; oxygen, 21 per cent). A mechanical treatment of air rich in oxygen was tried, but a complete separation of the two gases was not possible. This process was abandoned, but, without doubt, the last word has not been said, and there is still the possibility of it being applied industrially some day.

Boussingault devised a method for the extraction of the oxygen from the air which is still being used, although going out of use. It consists in gently heating baryta (BaO) to dull redness in air. The oxygen combines with the baryta, forming the dioxide (BaO_2), but at a bright red heat, this parts with the additional oxygen, with the reproduction of the baryta. By thus alternately varying the temperature, a regular production of gas can be obtained. This simple method, somewhat modified, was previously carried out on a large scale by Brin's Oxygen Company.

The process of Mothay and Marichal consisted in passing air over a heated mixture of manganese dioxide and soda. The substance absorbs the oxygen, and is converted into manganate. Water vapor is then passed over the maganate to decompose it, that is, to liberate the oxygen which it has absorbed, which regenerates the mixture of manganese dioxide and soda. This process of manufacture has many disadvantages and has been abandoned.

During the last few years the economical production of oxygen has been obtained by the liquification of air, and the separation into its two constituents.

Professor Linde was the first to work out an industrial for the liquification of air, and for the separation of the liquid into its two constituents, oxygen and nitrogen.

Claude, Pictet, Levy, Helbronner, etc., completed the problem and designed extremely ingenious plant, destined for the economical production of liquid air, and its rational distillation.

These are the main outlines of the operations. The air to be liquified is first compressed, then expanded; this lowers its temperature, and ultimately reaches liquification profiting (Claude process) by the work of expansion.

Although the oxygen and nitrogen liquify simultaneously, M. Claude succeeded in obtaining the first jet of liquid, rich in oxygen, which by a process of rectification, gets rid little by little of its nitrogen. The Linde process consists of the fractional distillation of liquid air, which brings about the production of pure oxygen. Other plants have been designed, besides these, using more or less these two systems, or their combination, hence the patents and claims of these are contested by others.

As a general conclusion one might say that the liquid air process is the most economical. Moreover, it is the one which has been most developed; the obtaining of the autogenous welds economically is a result of the lowering of the price of oxygen, due to the process.

ACETYLENE.

Properties of Acetylene.

Acetylene was discovered in 1836 by Humphrey Davy, an English chemist, and Perzelius, a Swiss chemist. They found that the residue which had been obtained incidentally in the production of metallic potassium was capable of decomposing water, with the evolution of a gas which contained acetylene. It is also produced during the incomplete combustion of certain gases. Thus, when a bunsen burner lights at the bottom, acetylene is produced. But until the industrial manufacture of calcium carbide, it remained a laboratory gas.

Chemically, acetylene consists of carbon and hydrogen, and is represented by the formula C_2H_2, meaning that it has the constant composition of 24 parts by weight of carbon, and two parts of hydrogen, or 92.3 per cent of carbon and 7.7 per cent of hydrogen. Of all the hydrocarbons, it is the richest in carbon. Acetylene is a colorless gas, which, when pure, has an odor which is not

unpleasant. The penetrating and disagreeable odor is due to impurities, notably phosphoretted hydrogen, hydrogen sulphid, and the polymers of the gas. These latter result from the heat generated in certain generators.

Acetylene is lighter than air, in the proportion 91 to 100; its specific gravity, or density, is therefore said to be 0.91. One cubic foot of the gas weighs 0.074 pound. One pound of the gas occupies 13.65 cubic feet, under standard temperature and pressure.

Acetylene is soluble in a large number of liquids; under ordinary temperature and pressure, water dissolves little more than its own volume, essence of turpentine and petrol 2 volumes, benzine 4, pure alcohol 6, and acetone 25. The solubility increases with the pressure. Acetylene is scarcely soluble in water saturated with marine salt. When heated to a temperature of about 600° C., acetylene polymerises into a number of products more or less related to benzine. The formation of benzine by polymerisation takes place with disengagement of heat (178 calories or 44 British thermal units).

Acetylene under atmospheric pressure becomes a liquid at 82° C. and a solid at 85° C. Acetylene under no pressure or under a slight pressure is not explosive, but this is not the case when compressed. Berthelot showed that acetylene subjected to pressure of 1½ atmospheres can decompose into its elements under the influence of a shock, slight heating, or any percussion whatever. Such decomposition produces a violent explosion. In practice the maximum should be much lower than this, and acetylene should never be kept under a pressure of more than a few pounds. The regulations forbid it. On the other hand, acetylene, absorbed under pressure by liquids which dissolve it, such as acetone, is absolutely safe.

Acetylene is an endothermic body, that is to say, it is formed with the absorption of heat. Thus heat is entirely given up again at the moment of dissociation, thus contributing powerfully to the rise of temperature, when combustion takes place.

Mixtures of acetylene and air, and, of course, more so of acetylene and oxygen, explode violently when ignited. The temperature of ignition being very low, a spark is sufficient to ignite the mixture. The formation of such mixtures should be avoided, and most certainly their ignition. The propagation of the flame can take place through extremely small orifices. The explosion of a vessel of one quart capacity, containing a mixture of acetylene and

oxygen, is sufficiently violent to cause the death of a person in the vicinity. It is extremely easy to avoid the formation of these mixtures, as we shall see later.

The properties of acetylene, such as heat of combustion, products of combustion, and temperature of the flame, have already been given.

Carbid of Calcium.

Composition and properties of carbid of calcium.

The discovery of the manufacture of carbid of calcium was due to the work of the French chemist, Moissan, and the American electrometallurgist, Wilson. The first communication was made to the *Academie des Sciences* by Moissan on December 12, 1892.

Chemically, carbid of calcium consists of calcium and carbon, and is represented by the formula CaC_2. It consists of 62.5 per cent of alccium and 37.5 per cent carbon. The color varies from earthy gray to luminous black, sometimes possessing a range of colors similar to tempered steel; the texture is usually massive, and crystalline, but sometimes spongy; but neither the color nor texture serves to indicate the good or bad qaulities of the carbid. Carbid of calcium has the hardness of stone. The specific gravity varies from 2.2 to 2.3. It is non-inflammable; it softens and melts at about 3,000° C.

In the presence of water vapor or water, the carbid decomposes into acetylene gas, and oxide of calcium (lime).

$$\begin{array}{l} CaC_2 + H_2O = CaO + C_2H_2 \\ \quad 64 + 18 = 56 + 26 \end{array}$$

According to this equation, 64 parts by weight of carbid requires 18 parts by weight of water, or one pound of carbid, requires 0.225 pint of water. These are theoretical quantities because we must take into account the evaporation of the water and the absorption of water by the lime, forming quicklime. In practice, it is necessary to use 1.2 to 1.6 pints of water for each pound of carbid, in those generators known as "water to carbid" and the "dipping" process 5 to 5.5 pints in "carbid to water." These quantities ensure that the lime residue may be removed in liquid form.

Theoretically, 1 pound of carbid yields 5½ cubic feet of acetylene at standard temperature and pressure. The reaction is always accompanied by rapid liberation of heat (226 calories, or 900 British thermal units for each pound of carbid).

Manufacture of Carbid.

Carbid of calcium is made by fusing a mixture of lime and carbon (coke or anthracite) in the proportion of 56 parts by weight of lime to 36 parts by weight of carbon, in the electric furnace, the temperature of which is about 4,000° C. The carbon should not contain more than 5 per cent ash, and the lime should be as free as possible from phosphates.

The economical production of carbid depends, to a great extent, upon the low price of electrical energy. Manufacturers of carbide cannot establish themselves unless a minimum water power of 2,000 to 3,000 horsepower can be utilised.

Under the enormous temperature of the electric furnace, the lime and carbon combined, and the liquid carbid which results flows like a jet of fire, then cools, and solidifies in large blocks. As soon as they are sufficiently cooled, the blocks of carbid are conveyed to the crushing and granulating room. The carbid passes through the crushers, the pieces being then graded, according to size by sieves, the dust being eliminated. One part of the crushed carbid is carried to the granulating apparatus, which separates it into pieces of regular dimensions. The carbid is immediately jacked in drums, the covers of which are hermetically sealed.

Discovery of the Welding Torch.

The use of oxy-acetylene welding is little more than 16 years old, since the blowpipes, working with acetylene under pressure, were made in 1901 by M. N. Fouche and Picard. From 1903 it has been applied industrially, and the progress of the process has been extremely rapid.

In 1895, M. Le Chatelier, in a paper read before the *Academie des Sciences* on the temperature of flames, stated that, Acetylene, burnt with an equal volume of oxygen gives a temperature which is 1,000° C. higher than the oxy-hydrogen flame. The products of the combustion are carbon-monoxide and hydrogen, which are reducing agents, and the paper concluded with this sentence: "This double property makes the use of acetylene in blowpipes of very great value for the production of high temperatures in the laboratory."

As was first pointed out by M. Chatelier, the oxy-acetylene flame results from the combustion of a mixture of oxygen and acetylene in equal volumes. Theoretically it required 2½ volumes

of oxygen to completely burn one volume of acetylene, and this is actually what takes place if one takes into account the oxygen taken from the air during the last phase of the combustion; but the blowpipe need only supply the oxygen necessary to form the white welding jet, and for this the volume is exactly 1 volume to 1 volume.

We shall see that in practice one requires a little more (1.2 to 1.4 for 1) because the mixture of the two gases is not absolutely perfect. For those who are not afraid of chemical formulæ, I will give the equations representing the phases of oxy-acetylene combustion.

Burnt with an equal volume of oxygen, acetylene produces hydrogen and carbon-monoxide:

$$C_2H_2 + 2O = H_2 + 2\,CO$$

Acetylene and oxygen yield hydrogen and carbon-monoxide.

The hydrogen and oxide next burn, taking the necessary oxygen from the air and producing water vapor and carbon-monoxide.

$$CO + O = CO_2$$

Carbon monoxide and oxygen yield carbon-dioxide.

$$H_2 + O = H_2O$$

Hydrogen and oxygen yield water vapor.

The carbon-monoxide formed in the first part of the combustion is therefore entirely burnt in the second, and it could not be otherwise unless one deprived the flame of air. A paper by M. Mauricheau-Beaupré to the *Academie des Sciences* in January, 1906, describes a series of tests which point to the complete absence of carbon-monoxide in the atmosphere surrounding the oxyacetylene fame. Poisoning of welders has therefore never existed except in the imagination of manufacturers of blowpipes for gases other than acetylene.

The combustion of 1 cubic foot of acetylene produces 410 calories, or 1630 British thermal units, nearly five times as much as that of hydrogen, and three times as much as oil gas. Of these 68 calories or 270 British thermal units are due to the heat of dissociation of the acetylene, is an endothermic gas, and disengaging suddenly at the moment of its decomposition, explains the very high temperature at the beginning of the flame. Observe that the other gases which are used in autogenous welding do not possess this remarkable property.

The temperature of the oxy-acetylene flame, taken at the extremity of the white jet, is very much higher than that of all other

flames. M. Chatelier calculates it to be 4,000° C. or more than 7,000° F. in all cases; the white jet of the oxy-acetylene flame can melt lime, the melting point of which is estimated at 3,000° C., and this can only be obtained otherwise in the electric arc.

The final products of combustion are, as we have said, carbon dioxide, and water vapor, this latter in a less quantity than for the oxy-hydrogen flame, but the molten metal under the action of the flame only comes in contact with the carbon-monoxide and the hydrogen produced in the first stage of combustion, since the welding is done at the extremity of the white jet. These gases, which have a reducing action, are in all cases the most neutral, considered from the physical and chemical point of views as capable of modifying the value of the weld. The utilization of the heat of the flame, or the coefficient of utilization is very high in the case of the oxy-acetylene flame, on account of the high temperature of the flame being concentrated at the point of the flame (white jet).

WILLIAM BUEL FRANKLIN.

By

Lieut. James H. England,
Engineers, National Army.

William Buel Franklin was born in York, Pa., on the 27th of February, 1823. His father, Walter S. Franklin, was Clerk of the House of Representatives in Washington. His mother was a daughter of William Buel, of Litchfield, Conn. He entered the Military Academy as a cadet July 1, 1839, and was graduated first in the class of 1843 as a Brevet Second Lieutenant of Topographical Engineers. Among his classmates were Gen. Isaac F. Quinby, Gen. James A. Hardie, Gen. Christopher C. Augur, Gen. Ulysses S. Grant, Gen. Joseph H. Potter, and Gen. Rufus Ingalls.

Upon leaving the Military Academy, he was assigned to duty in field work in the West. He served as Assistant Topographical Engineer on a survey of the Northwestern Lakes and as Topographical Officer on General Kearny's Expedition to the South Pass of the Rocky Mountains. He was then assigned to duty in Washington and elsewhere about the East until the outbreak of the Mexican War. On September 21st, 1846, he was promoted to be Second Lieutenant and, when hostilities against Mexico commenced, was assigned to duty as Topographical Engineer on the staff of General Taylor. At the battle of Buena Vista he was brevetted for gallantry. At the close of the Mexican War, in 1848, he held the position of Assistant Professor of Natural and Experimental Philosophy at the Military Academy for two years. He then became engaged in the construction of coast defense works and in 1853 was assigned to the Light House Service. He was promoted to be First Lieutenant in the Topographical Engineers, on March 3rd, 1853, and to be Captain in the same corps in 1857. From 1859 to 1861 he was Superintendent of the Capitol and Post-office Building in Washington, and then Supervising Architect of the Treasury Department. During this time he built the first bridge across the Mississippi at Rock Island. When the Civil War

commenced, he was appointed Colonel of the Twelfth United States Infantry and on the 17th of May, 1861, Brigadier-General of Volunteers. He was assigned to the command of a brigade in Heintzelman's division under McDowell and served at Bull Run, where his command lost heavily. In the reorganization of the Army, which followed the affair at Bull Run, he was ordered to the command of a division.

The Army of the Potomac took the field in the spring of 1861, under the immediate command of Major General George B. McClellan. Franklin's division was assigned to the First Corps and he subsequently joined McClellan on the Peninsula. After the evacuation of Yorktown by the Confederates, he had a sharp affair with the left flank of the retiring Confederate force at White House. At this time two provisional corps, the Fifth and the Sixth, were created by order of General McClellan. General Franklin was assigned to the command of the Sixth Provisional Corps, consisting of his own division and that of General Slocum.

Franklin's troops were heavily engaged during the battle of Gaines Mill on both sides of the Chickahominy. When the flank movement to the James River commenced, he covered the withdrawal of the Army; protected the passage of the White Oak Swamp, and took part in the battle of Malvern Hill. On June 30th, 1862, Franklin was brevetted Brigadier General United States Army, for gallant and meritorious conduct in the battle before Richmond, Va. In the Maryland campaign he was in command of the Sixth Corps of the Army of the Potomac and was engaged in the battle of Cramptons Gap, the battle of Antietam, and the march to Falmouth. His arrival on the field of Antietam, where the battle had already commenced, was singularly timely and averted what might have been a disaster on the right, where Sumner and Hooker had been severely handled.

On July 4, 1862, Franklin was appointed Major General, United States Volunteers.

On October 6, 1862, General McClellan received an order from President Lincoln to ''cross the Potomac and give battle to the enemy or drive him south.'' McClellan determined upon the Shenandoah Valley as the scene of his immediate operations. To this end he ordered the army to cross the Potomac at and below Harpers Ferry. The crossing was begun on October 26th and by November 7th the Army of the Potomac was concentrated in the neighborhood of Warrenton. On this same day McClellan was relieved from

command of the army and Burnside was appointed in his place. The change occasioned surprise, because it was unexpected and so was the selection of the new commander. Burnside, Hooker, Sumner, and Franklin had been suggested; of these, Franklin was far superior in point of ability. He was a safe and careful commander and had recently shown at Sharpsburgh that he possessed a true appreciation of the military situation on the field of battle.

General Burnside discarded General McClellan's plan and decided to march on Fredericksburg and from Fredericksburg directly on Richmond; to move along the north side of the Rappahannock towards Fredericksburg, and, when opposite the town, cross the river on ponton bridges. On November 10th the Army was organized in three Grand Divisions and a Reserve Corps, and Franklin was placed in command of the left Grand Division. On the morning of the 15th the march began and by the 19th the Army had reached Falmouth, a town almost opposite to Fredericksburg. Everything was ready for the crossing but the bridge. It was not until December 11th that the crossing was attempted. Two ponton-bridges were planned to be built directly in front of Fredericksburg and two more about 2 miles below the town. These lower bridges were built without difficulty and Franklin's troops were in position on the south side of the river. The building of the upper bridges was attended with more difficulties.

On the 12th of December, Franklin urged Burnside to give orders that would enable Franklin to attack the Confederate extreme right. It was perfectly plain that this was the operation most likely to succeed. Even with such a movement successfully consummated the issue of the battle would have been far from certain. Without even attempting it, defeat was inevitable. Burnside refused to issue the necessary orders and Franklin could not make the attack. The bloody defeat suffered by the Army of the Potomac on the next day, December 13th, is a matter of history. The loss on the Union side was 12,653 men, 5,000 of whom were of Franklin's Division.

After the withdrawal from Fredericksburg, a change of commanders was again made in the Army of the Potomac, Hooker succeeding Burnside. With this change came the relieving of General Franklin from the command of the Left Grand Division and his retirement from service with the Army of the Potomac.

Shortly afterwards General Franklin was sent to the Depart-

ment of the Gulf, where he took command of the Nineteenth Corps, serving under General Banks. The most conspicuous event of his service in the southwest was the Red River expedition. General Banks was so overcome by the disaster to this expedition that he turned over the active control of all subsequent operations to Franklin. During this period Franklin rescued Admiral Porter's fleet by the building of a dam, the credit for which has been claimed by several officers who served under him in its construction.

At the battle of Sabine Cross Roads, April 8, 1864, he was wounded and shortly after left on sick leave. On his way home, the train on which he was riding was captured by guerilla cavalry under Gilmore. Franklin was taken prisoner, but escaped during the night and managed to make his way to Baltimore. This was the last event in General Franklin's military service in the field.

For gallant and meritorious services in the field during the Rebellion, Franklin was brevetted Major-General, United States Army, March 13th, 1865. He served as President of a Retiring Board at Washington during 1865. His military career ended on March 15th, 1866, when he resigned from the Army.

Congress, in 1880, elected him as one of the managers of the National Soldiers' Home, and he served as president of the board for twenty years, until his health compelled his retirement. He served also for a short term as Adjutant General of the State of Connecticut, and also as a Presidential Elector. He was appointed United States Commissioner General to the Paris Exposition, and received from the French Government the Grand Cross of the Legion of Honor. Up to the time of his death he took an active part in civic affairs of his home city, Hartford, Conn., having served in numerous public capacities. He died at Hartford on March 8th, 1903.

The following tribute to General Franklin's character is taken from the sketch written by Col. J. L. Greene, of Hartford.

There are men whose influence upon their times and whose impress on men's memories come from the unusual development and activity of certain specific but limited abilities, or from special traits of character. An unusually energetic exhibition of even a moderate amount of these may make their possessor strikingly prominent under favorable circumstances, the more so perhaps for their onesidedness. There are those, again, whose mark is made, not by a few strong points of either mind or character standing out from the background of an otherwise commonplace personality, but by mental powers of unusual breadth and force and traits of character of unusual value, and yet all so full rounded and

balanced, so harmonious in blending and in exercise, so free from defect in structure and from noise in action, that not until by long opportunity men have measured them and their work with other standards of being and doing, do their strength and beauty stand revealed in full and impressive majesty.

General Franklin was distinctly of this type. Physically, intellectually and spiritually, he was built upon a magnificent model. As a scholar of the first order in his chosen lines of study, and sympathetic with all intellectual life and effort, as a man of action, clear in insight and in thought, broad and strong in his grasp, certain in judgment, definite, direct, prompt and vigorous in action, peculiarly diligent in attention to duties of whatever magnitude, pure and high-minded, with an integrity that never left his vision at fault and a courage that never hesitated, wise, prudent and strong, simple, kindly, of perfect but unconscious dignity, he presented a rare balance of great gifts. . . .

So quietly and unostentatiously was all his work done that only upon a full and detailed survey can the great magnitude of it all, and the great importance of its many parts and the invariable high standard of its excellence, be appreciated. But those who knew the strength and uprightness of his mind and character, the kindliness of his heart, his noble simplicity and personal dignity, his ready devotion to every patriotic interest and duty, the loyalty of his nature and the purity and unaffected piety of his life, know that one of the bravest of gentlemen, one of the purest of patriots, one of the most cherished of friends and one of the knightliest of men, has answered to his name.

RIVER CROSSINGS

Extracts From

"TACTICS AND TECHNIQUE OF RIVER CROSSINGS"[1]

By

General Mertens
German Army

GENERAL VON FALKENHAUSEN'S PROBLEM[2]

. . . .

The following discussion is likewise to furnish an informal elucidation of the principles enumerated in the chapters on "River Crossings" and on "Defense against a Hostile Crossing."

SITUATION.

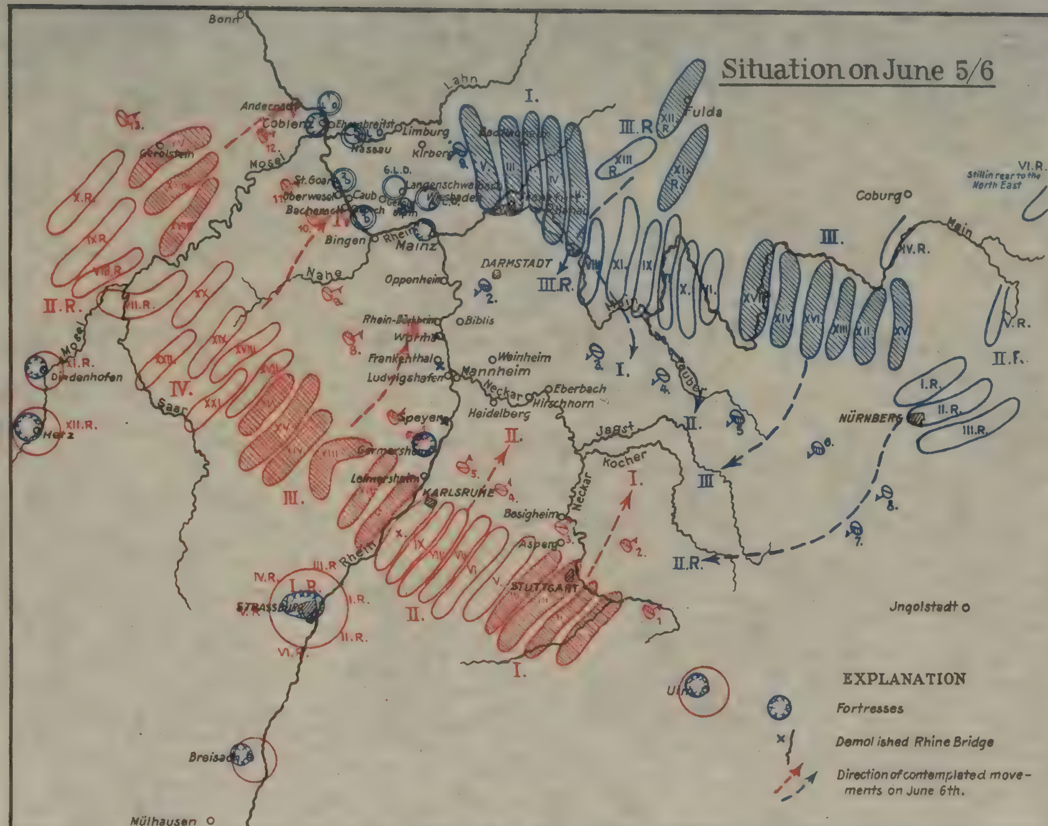
A Blue army group composed of the Ist, IId, and IIId Armies, in all 17 army corps and 7 cavalry divisions, after having both flanks turned by a superior Red army group composed of the Ist, IId, IIId, IVth, and Vth Armies and the Ist and IId Reserve Armies, in all 37 army corps and 13 cavalry divisions, fell back before it from the line Metz-Strassburg-Breisach to the line of the Main. The Red army group followed, its right wing crossing the Rhine between Breisach and Strassburg, its left moving along the Moselle. Its advance was retarded by inadequate communications (it being necessary to throw a number of bridges across the Rhine, the Saar and the Moselle) and by delays in front of the fortresses, which were invested.

The Blues brought reinforcements up by rail, the IId Reserve Army (5 army corps) on their left wing, the IIId Reserve Army (3 army corps) in rear of their right wing. The position of the opposing army groups on June 5th, is shown on Map 2.

It was important for the *Blues* to take advantage of the division of the hostile forces caused by the Rhine and its fortresses and to assume the offensive again with the arrival of their reinforcements. They still felt superior to the Red forces that had already crossed to the right bank of the Rhine. By moving rapidly by their left, they intended to strike the Red right wing and to defeat

[1]Reprinted, by permission, from "Tactics and Technique of River Crossings," by Mertens, Colonel and Chief of Section in the Engineer Committee, German Army (translated by Walter Krueger, Major and Assistant Chief of Staff 84th Division, National Army). D. Van Nostrand Company, New York. (See Book Review.)

[2]"*Flankenbewegung und Massenheer,*" by General von Falkenhausen, Berlin, 1911. Published by E. S. Mittler und Sohn, Kgl. Hofbuchhandlung, Kochstrasse, 68-71.



Central Map Reproduction Plant, Engineer School, Washington Barracks, D.C.

it decisively before the Red troops advancing probably between Strassburg-Germensheim-Mayence [Mainz] and north of the latter fortress, could fall upon their own right wing and rear. The advance of Red forces north of Mayence was to be delayed as much as possible by six Landwehr divisions stationed there, and a Red advance south of Mayence was to be prevented by demolishing all bridges over the Rhine that were not protected by fortresses.

The Blue main armies began their flank movement on June 6th. On this and the next day, the *Reds* did not as yet have definite information of the Blue offensive nor of their movement to turn the Red right flank. But one thing was certain, it was absolutely essential to reach the right bank of the Rhine as quickly as possible with all the corps still on the left bank. Accordingly the Red IIId, IVth and Vth Armies were ordered to cross the river as expeditiously as possible. For this, the section of the Rhine between Mannheim and Mayence was assigned to the IIId, that between Mayence and Coblence to the IVth and that north of Coblence to the Vth Army. The IId Army was to throw two bridges over the Rhine, one on either side of Germersheim, in order to improve its communications to the rear. Leimersheim and Speier were selected as sites for these bridges.

The Situation on the Rhine on June 6th and the Operations from June 6th to 9th.

I. *South of Mayence.*

The Red IIId Army, advancing toward the Rhine south of Mayence with 3 cavalry divisions and 6 corps, intended to cross with 3 corps at Mannheim and with 2 corps at Worms. One corps was to neutralize Mayence. The necessary bridge construction work was entrusted to the XIth and XIVth Army Corps.

All corps were to put their pioneers and bridge trains well forward in their columns and to place them at the disposal of the two above mentioned corps when they asked for them.

The Blues had had weak Landsturm detachments (each consisting of one battalion of 3 companies, 1 escadron, and one third of a pioneer company) at the Rhine bridges north of Germersheim, at Worms, Mannheim, and Speier [Speyer], ever since the campaign opened. They had seized all ferries in the vicinity, and had collected all boats on the right bank at the three cities named. The local protection of the Rhine bridges, which had been prepared for demolition, was entrusted to them, and, in addition, after com-

pleting the destruction—should that become necessary, and after removing all ferries, they were to oppose a hostile crossing as far as their strength permitted.

Let us now turn to the situation at Mannheim and examine it a little more closely.

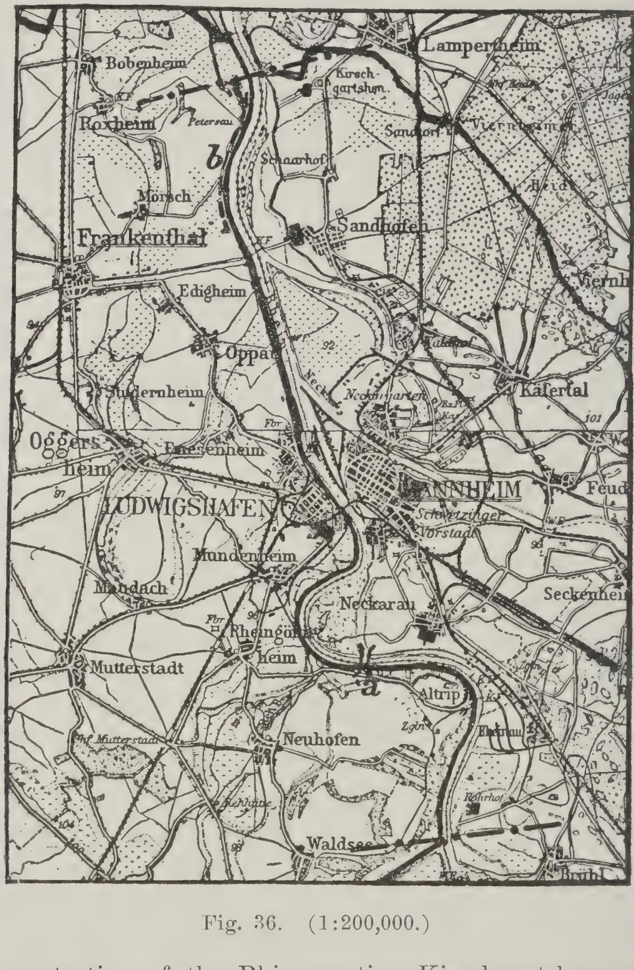


Fig. 36. (1:200,000.)

The protection of the Rhine section Kirschgartshausen-Mannheim-river bend 4 km. south of Altrip (see Fig. 36), was entrusted to the detachment stationed at Mannheim. Its dispositions were as follows: one company of infantry and one-fourth escadron was in Sandhofen, one platoon being sent to Kirschgartshausen; the 2d Company and one-half escadron had temporarily

occupied Ludwigshafen; outguards under noncommissioned officers were posted at the Neckar bridges northeast and east of Mannheim; the 3d Company and one-fourth escadron was at Neckarau and covered the Rhine to the southern extremity of the battalion sector, one platoon being posted in advance of Rohrhof. Outguards had been pushed to the Rhine and patrols were ordered sent from Ludwigshafen and across the Rhine in a westerly and southwesterly direction and also along the right bank of the Rhine. Auto busses were held in readiness at Mannheim castle for one platoon of the center company so that it could be quickly sent to any threatened point. All Rhine and Neckar bridges within the sector held by the detachment had been prepared for demolition by the pioneers. All important long distance telephone stations within its sector had been occupied. The detachment was connected by wire with the general headquarters on the Main.

The order for destroying the Rhine bridge was received during the night 5-6 June and was carried out during the early morning hours of the 6th, after all the troops but one platoon of infantry and three troopers (all good swimmers) had been withdrawn. Manned boats were held in readiness in Ludwigshafen to enable them to effect their escape.

The *Red* 6th Cavalry Division advanced against this line on June 6th. Its patrols received a lively fire from the edge of Ludwigshafen. As no reliable information had as yet been received as to the destruction of the Rhine bridge there, and as it was still hoped to get possession of it intact, the bulk of the division advanced against Ludwigshafen, whose streets were obstructed by many barricades, and by noon the town was in Red hands, the weak Blue garrison having made good its escape to the right of the Rhine after suffering some loss. One cavalry brigade advanced toward the Rhine via Frankenthal, but found the river so strongly occupied by hostile infantry that a crossing by day appeared hopeless.[1]

During the afternoon, a General Staff Officer and the commander of the pioneer battalion of the Red XIth Army Corps, escorted by a strong patrol, arrived in Ludwigshafen to reconnoiter the crossing. This reconnaissance developed that one 90 m. span of the very elevated Rhine bridge had been thrown into

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[1]The cavalry division might, perhaps, have been able to cross the Rhine at once, had it been accompanied by a battalion of infantry.

the river. To repair this damage quickly was out of the question. It was considered necessary to build a ponton bridge and, preferably, to avoid the large city. A suitable bridge site was found at a brick yard 2 km. northwest of Altrip, the width of the channel at that point being estimated at 300 m.[1] As definite information in regard to the strength of the troops on the right bank of the Rhine was not as yet available, and it did not seem improbable that a strong force of troops might have to be thrown across, it was deemed advisable to order up 4 divisional and 2½ corps bridge trains. In view of reports previously received from aviators, however, the corps commander believed that he need not anticipate a stubborn resistance and therefore determined to force the crossing of the Rhine during the daytime. Five companies of pioneers appeared to be requisite for promptly carrying out the enterprise.

It was highly desirable to have the 6th Cavalry Division cross the Rhine as quickly as possible. Its crossing was to be effected during the following night on the apparently but weakly guarded section east of the line Mörsch-Petersau and north thereof. Two divisional bridge trains and two platoons of pioneers were to assist the 6th Cavalry Division and were to arrive in Frankenthal at midnight.

For the purpose of deceiving the enemy and to draw some of his force off, one cavalry brigade made ostentatious preparations to cross opposite Rheingönnheim in the course of the afternoon, and the bridge wagons of the cavalry division were assembled in Frankenthal. The banks of the Rhine north of the line Frankenthal-Sandhofen were reconnoitered with great secrecy and it was decided to cross there on a broad front. (See the line at *b* in Fig. 36.) The crossing was effected at 2 a. m., June 7th. Two escadrons sent toward the boat ferry west of Sandhofen at 1.30 a. m., managed to lure the hostile infantry posted in Sandhofen to the ferry. By 3 a. m., enough dismounted troopers had been landed without appreciable losses northwest of Sandhofen with the assistance of the pioneers of the XIIIth Army Corps, who arrived punctually on their two divisional bridge trains, to put the Reds in secure possession of the right bank

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[1]General von Falkenhausen in his study locates this new bridge in the vicinity of the one demolished, probably because he does not consider the conditions for an advance by Neckarau particularly favorable.

and to enable them to begin swimming their horses across. By 9 a. m. two brigades of the division—minus their wagons, were on the right bank.[1] The crossing of the 3d Brigade, as well as of the guns and carriages, over a flying bridge that had meanwhile been constructed, consumed the remaining daylight hours of the 7th. The Blues made an abortive attempt from Sandhofen and Kirschgartshausen to interfere with the crossing.

Meantime, the XIth Corps had made arrangements to concentrate the bridge trains of the XIth, XIIth and XIIIth Army Corps, which had been placed at its disposal by the Army Commander, on Ludwigshafen. The bridge trains of the XIth Army Corps arrived with the advance guard of that corps at Neuhofen about noon of the 7th. Toward 4 p. m., the leading division of the XIth Army Corps had posted strong artillery southeast of Rheingönnheim and north and northwest of Neuhofen, whose vigorous fire broke down the resistance of the hostile landsturm company in Neckarau so quickly that the Red infantry crossing east of Rheingönnheim encountered only very little resistance. When the artillery of the 6th Cavalry Division likewise opened fire from the north on the Landsturm detachment at Mannheim, the whole Blue detachment decided to withdraw and retired behind the Neckar, where, toward evening, the heads of the Blue 2d Cavalry Division arrived. The Neckar bridges were not destroyed for the present but, including those in Mannheim, remained in Blue hands. The construction of the bridge southeast of Neckarau (at *a*, Fig. 36) had, meanwhile, begun, but could not be completed until the morning of June 8th, as the bridge trains of the XIIth and XIIIth Army Corps did not arrive until late, due to the long distance they had to march—about 60 km. The Red corps began the passage of the Rhine at 10 a. m. June 8th, and completed it at noon on the 10th.

Events at Worms progressed in a similar manner. Here, likewise, where in the course of June 6th, the Landsturm troops were reinforced by the leading elements of the advancing Blue 1st Cavalry Division, the Reds were unable to get the Rhine bridges into their possession intact. The Red 7th Cavalry Division, reinforced by pioneers and two divisional bridge trains, therefore crossed the Rhine during the night of June 6 and 7, at Oppenheim, 25 km. north of Worms, without encountering hostile opposition.

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[1]This good showing was possible only because the horses swam in droves.

At Worms itself, after the resistance of small hostile detachments had been broken down by fire, as at Mannheim, a bridge was thrown across the Rhine during June 8th and the succeeding night.

On June 9th, the Red IId Army caused bridges to be thrown across the Rhine at Leimersheim (south of Germersheim), and at Speier. At both places, the right bank was free from hostile Landsturm troops, for they had already been compelled to evacuate their positions at the river by the advance of the Red IId Army on the right bank of the Rhine, and had retired behind the Neckar. The garrison of Germersheim made repeated attempts to destroy the bridge at Speier by floating rafts and boats against it, but these enterprises were foiled by the vigilance of the Red river guard.

2. *North of Mayence.*

As stated above, six Blue landwehr divisions were available north of Mayence for opposing the advance of the Reds there. The commander of the Landwehr had divided his force into two groups, which rested, respectively, on the fortresses Mayence and Coblence. The divisions remained intact, but small detachments were pushed forward to cover the Rhine directly, and on the left bank of that river a few patrols made vain attempts to maintain their positions against the advancing strong Red cavalry.

If the enemy had crossed within reach of the divisions, the latter would undoubtedly have assumed the offensive against him. But the commander of the Landwehr believed that, in view of his comparatively weak force, the best plan would be to delay the enemy as much as possible after the latter had crossed the river, without exposing himself to attack by superior forces, and to draw the hostile corps by suitable operations away from the Blue main army south to the Main.[1]

Although the Rhine itself was guarded by weak forces only, the Red cavalry divisions, whose leading elements reached the

[1] It is debatable whether it might not have been better to distribute the Blue Landwehr divisions in cordon formation along the Rhine (from Mayence to a point half-way to Coblence-Bonn). The task of the comparatively weak Blue force, in view of the decided Red superiority, the magnitude of the stream (with its width of 300-400 m.), and the proximity of the fortresses, all favor that solution. Although the Blue forces succeeded, as the subsequent course of events will show, to retard the Reds sufficiently east of the Rhine, they failed to delay their opponent appreciably anywhere along the strong Rhine barrier itself.

river between Mayence and Coblence on June 6th, did not succeed in throwing adequate forces across to the right bank on that and the succeeding day. Only a few patrols swam across. The advance was, therefore, for the time being at least, halted, and meanwhile the leading elements of succeeding corps of the IVth Army were beginning to arrive at the Rhine.

The Red 12th Cavalry Division, which advanced toward the Rhine north of Coblence, had better luck. (See Fig. 37.) In this locality, the bulk of the Blue 1st Landwehr Division was posted in the district Vallendar-Bendorf; one battalion had occupied Neuwied, and one escadron was stationed opposite Andernach, and formed the northernmost covering force. The Blue patrol service along the river bank between the points occupied was inadequate.—The Red 12th Cavalry Division arrived at Rübenach on the afternoon of June 6th, reconnoitered from there toward Coblence and the Rhine, and received reliable information from air scouts of the massing of strong hostile forces at Vallendar-Bendorf. Its commander did not care to make a wide detour to get across the Rhine, and therefore determined to trust to luck and to attempt a crossing in the gray of dawn on June 7th, at Andernach. During the 6th, the division remained under cover of the heights near Rübenach and only endeavored to obtain information in regard to the local conditions at Andernach and the strength of the hostile troops on the right bank of the river there. After nightfall it moved toward the selected crossing point. During the early morning hours of June 7th, one cavalry regiment managed, with such means as were available in the division itself, to swim across the Rhine unobserved between Weissenthurm and Andernach, and to force the completely surprised Blue escadron stationed near Fahr to retire on Rodenbach.[1] Later on, to be sure, this escadron and the battalion in Neuwied advanced against the Red troops that had crossed; the latter, however, had at once prepared Fahr and Wollendorf for defense and were vigorously supported by their divisional artillery, which had gone into position directly west of Andernach. Thus, the crossing, which had, meanwhile, been shifted farther down stream, toward Leutesdorf, could be continued, boats found in the vicinity being utilized. Toward noon, two Red cavalry brigades were assembled on the right bank and forthwith advanced on Isenburg.

[1]Extensive regulating work that was being done about this time on both banks of the river, facilitated getting the horses into and out of the stream.

The commander of the Blue 1st Landwehr Division did not deem it expedient to extend the line still farther northward, as it already stretched for 80 km. along the Rhine. His division accordingly remained in its positions north of Coblence and allowed the crossing of the Red cavalry division to proceed.

The moment had now arrived for the commander of the Red

Fig. 37. (1:200,000.)

Vth Army to make arrangements for the crossing of his various corps. In this connection, he clearly discerned the difficulties that a crossing and the construction of a bridge at Andernach would encounter in view of the proximity of strong Blue forces. It was calculated that, owing to the width and velocity of the stream, a corps bridge train would not be able to carry much more than a battalion of infantry across in an hour and that the construction

of the bridge would consume from 6 to 8 hours. If the hostile battalion at Neuwied and the strong hostile forces at Bendorf were to advance promptly against the crossing point, considerable interruptions would certainly have to be reckoned with. Nevertheless, the Army commander decided to trust to luck, as the 12th Cavalry Division had done, and to effect an accelerated crossing with the XXVth Army Corps at Andernach during the night of June 7 and 8, but to couple this with a demonstration opposite Engers.

Hostile air scouts, which constantly circled over the approaching Red columns (see Map 2), apparently kept the Blues well informed in regard to the Red advance. To deceive them became indispensable. Accordingly the various corps received orders not to let their main bodies advance beyond the line Lonnig-Ochtendung-Kruft,[1] but to have all the advance guards continue the march eastward on Coblence and to have all pioneers and bridge trains follow them. Thus it happened that Red troops reached Bassenheim and Laffig during the afternoon and that long bridge trains, clearly discernible to the hostile air scouts, assembled there. Extensive reconnaissances were initiated toward Engers and everything done to convince the enemy that a crossing was contemplated there. In Andernach, however, everything was quiet. But detail reconnaissances in preparation for throwing troops across and for constructing a bridge were made. The roads to be used by the bridge trains of the three corps, which were to be united there, were designated and arrangements made for lighting them at night. The last brigade of the 12th Cavalry Division to cross, was to advance to Niederbieber only, but during the night to occupy Irlich, which was free of the enemy, so as to cover the initial operation of throwing troops across.

The Blues in fact expected a crossing to be made at Engers, opposite which the advance guard of the XXIIId Army Corps made a lodgment at nightfall, while, at the same time, attempting to attract the attention of the Blues by making a demonstration with the attached bridge train of the leading division. The 1st Landwehr Division therefore remained in its positions in readiness to attack such covering troops as the enemy might throw across at Engers.

At nightfall, meanwhile, the XXVth Army Corps and all the

[1]This is, in minor details, a departure from the description in General von Falkenhausen's study.

pioneers and bridge trains of the three Red army corps had begun the march on Andernach. The bridge trains advanced directly to the districts assigned to them at the river (that of the XXIIId Army Corps east of Andernach, that of the XXIVth Army Corps in Andernach itself, and that of the XXVth Army Corps opposite Leutesdorf). Troops were begun to be ferried across the river at once at all points, and by 4 a. m. one brigade of infantry was on the right bank north of Irlich and field artillery of the corps had gone into a position in observation east and west of Andernach. The Blue forces made no move from Bendorf, and, in fact, did not report of the crossing until 5 a. m. To attempt anything now appeared useless to the Blues, and would, as a matter of fact, scarcely have interrupted the bridge work, which had meanwhile begun. The bridge, whose construction was begun at 11 p. m., was completed by 6 a. m. Thus the difficult crossing of the Rhine had been effected without losses.

It was now important quickly to pave the way between Mayence and Coblence for the crossing of the Red IVth Army. As already mentioned, the 9th, 10th and 11th Cavalry Divisions, advancing ahead of the IVth Army, had in vain attempted to swim the Rhine on June 6th and 7th. This technically very difficult undertaking had everywhere been foiled by the small detachments that had been pushed to the Rhine by the Blue 2d and 3d Landwehr Divisions, stationed respectively in Rüdesheim and in St. Goar. The commander of the Red IVth Army realized that it would be impossible to throw cavalry across here. He accordingly determined to concentrate at the Rhine on June 8th as many pioneers and bridge trains of the advancing corps as he could make available, and to break through the line of the two Blue Landwehr divisions by surprise, if possible, by force, if he must, at Bacharach and Oberwesel. The execution of this enterprise was entrusted to the XVIIIth and XIXth Army Corps, which arrived with their leading elements at Rheinböllen[1] and Kisselbach (10 km. southwest of Oberwesel) on the evening of June 7th.

Let us now take up in more detail the measures and events that led up to the crossing at Bacharach.

The dangers threatening the troops thrown across, in case they were attacked by superior Blue troops, was apparent even in the crossing at Andernach. In this case, the conditions were

[1]Immediately west of Dichtelbach.

similar, as the hostile main forces were at Rüdesheim only 15 km. away. It was therefore indispensable to deceive the enemy as to the crossing point. If he was held fast at some point other than the actual crossing point, the difficult terrain on the right bank, which had very few roads running along the stream, would benefit the Reds and might make the crossing succeed. In the case under discussion, therefore, the simplest plan appeared to be to contain the Blue 3d Landwehr Division at Bingen, in other words, to threaten with a crossing there.

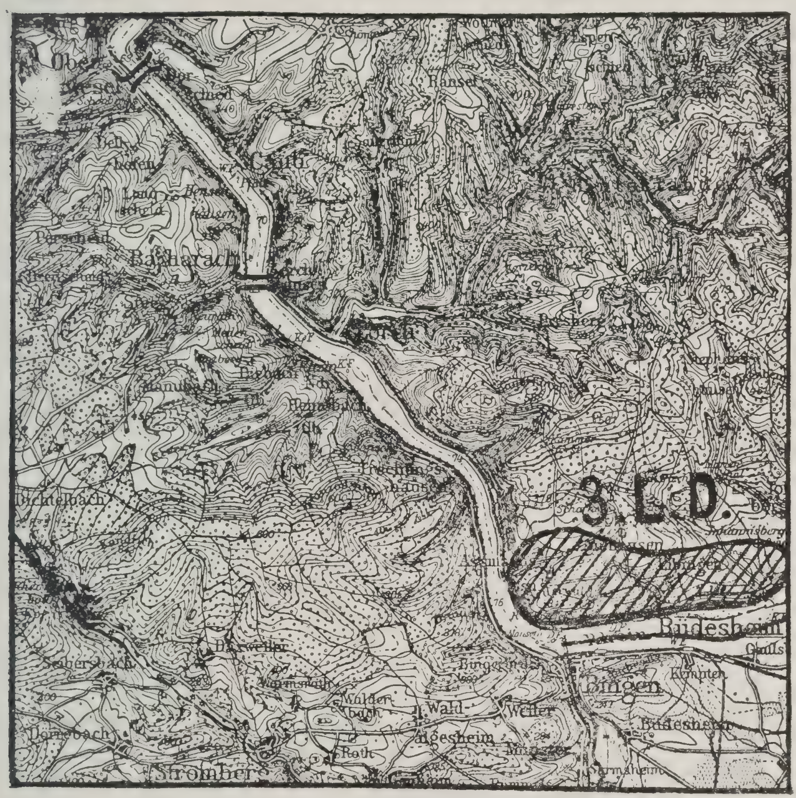

Fig. 38. (1:200,000.)

The heads of the Red XVIIth Army Corps arrived before Bingen on the 7th. On the afternoon of the 8th, the entire artillery of the corps deployed on the heights near Bingen and opened a vigorous fire on all positions and villages on the right bank of the Rhine wherever Blue troops showed themselves.

Toward evening, infantry was ferried to the Mauseturm Island on the pontons of the two divisional bridge trains of the XVIIth Corps and everything was done to make the Blue troops on the right bank believe that a crossing was impending.

It would have been exceedingly difficult to hide the movements of the bridge trains on June 7th and 8th from hostile air scouts, which here, likewise, continually circled over the advancing corps, had the trains marched during the daytime. It was impossible to bring them up to Bacharach in the daytime, for the presence of the long column would assuredly have been reported to the Blues and might have jeopardized the secrecy of the whole enterprise. All the corps had therefore been instructed as early as the 7th not to push their bridge trains (except the two divisional bridge trains of the XVIIth Army Corps) too close to the Rhine in the daytime, but to have them continue their march after nightfall and to conceal them until daybreak on the 8th, in the woods that extend along the road leading from Rheinböllen to Bacharach. This order was carried out without appreciable friction, and it was therefore easy to bring them and their accompanying pioneers quickly up to the crossing point at Bacharach.

With the exception of the XVIIth Army Corps, which, as already described, made a demonstration at Bingen, everything was quiet during the daylight hours of the 8th on the Red side, but a demonstration was made from Rheinböllen toward Stromberg by troops of the XVIIIth Army Corps for the purpose of deceiving hostile air scouts. After nightfall, however, the entire artillery of the XVIIIth Army Corps went into previously reconnoitered positions on the heights on both sides of Bacharach, infantry quietly occupied the bank of the Rhine as far as a point opposite Caub and Lorch and the pioneers and bridge trains of the XVIIth Army Corps (less two divisional bridge trains), and of the XVIIIth and XIXth Army Corps were brought up to Bacharach. All available pontons—except those of a single divisional bridge train, were quietly carried to the river, deposited in the rear of the railway embankment, and the troops to be thrown across stationed behind them. As there had been ample time to make all the necessary preparations without haste, the dawn of day was awaited with confidence. As soon as it was light enough, the Red artillery directed an overwhelming fire against all occupied localities on the opposite bank, especially against Lorch, Lorchhausen and Caub, where several Blue com-

panies were apparently posted. Soon thereafter the operation of ferrying troops across was begun, and this was scarcely molested by hostile infantry, which, whenever it showed itself, was at once downed by the superior fire of infantry, machine guns, and artillery. About three hours later, about one Red brigade of infantry had occupied the commanding heights on the opposite bank. Work on the bridge, which was started soon after daybreak, was completed toward 11 a. m. The Blue 3d Landwehr Division had not discovered until it was too late that it had been deceived at Bingen. As it could no longer hope to achieve success at Bacharach, it retired toward Wiesbaden.—Thus, the crossing of the Rhine at Bacharach had likewise been effected without serious losses, and the XVIIIth Army Corps began to cross the bridge; the other corps were to follow.

As soon as the Blue 3d Landwehr Division had withdrawn, the Red 9th Cavalry Division, whose crossing had so long been prevented by the Blues, at once began the operation of ferrying troops across at Rüdesheim. In this it was materially assisted by the two divisional bridge trains at Bingen and the pioneer company accompanying them. By nightfall of June 9th, all of it had reached the right bank of the Rhine.

The bridging operation at Oberwesel ran a similar course. The result of the operations on the 8th and 9th of June was, consequently, that reliable bridges were thrown across the Rhine, first at Andernach, and later at Bacharach and at Oberwesel, over which the various corps of the Red Vth and IVth armies passed, to the right bank of the Rhine without interruption. We shall later again revert to the movements of the Blue Landwehr Divisions that retired before them.

The Operations from June 7th to 10th.

As early as June 7th, the cavalry divisions of the *Red* Ist and IId Armies had clashed with the *Blue* cavalry divisions on the Kocher and the Neckar, south of Mayence. These engagements for the most part ended in favor of the Blues. But the Kocher and the lower Neckar nevertheless remained in Red hands and on June 8th the Red Ist and IId Armies moved into these sectors. On the same day, the Red IIId Army, the XIth Corps leading, began crossing the Rhine bridge at Mannheim and occupied the neighborhood of Weinheim, thus forming a junction with the Red IId Army.

Meantime, the flank movement of the Blue armies had made

good progress. The Blue IId Reserve Army, after a series of long marches, had reached the extreme left flank, thereby outflanking the Red troops stationed along the Kocher. The Blue IId and IIId Armies moved directly forward against the front of the hostile line with the object of holding it fast. In this they were only partially successful. The object of the Blue offensive movement was becoming more and more apparent to the Reds. To evade it, the Red Ist Army accordingly retired to the Nackar during the night of June 9 and 10, the Blue IId and IIId Armies followed, and on the evening of the 10th these two forces confronted each other on the Neckar.

While the Reds had so far managed to evade decisive blows on the right flank, their IIId Army, which had crossed the Rhine at Worms and Mannheim, was no longer able to do this. In this locality, the Blue IIId Reserve Army had been transferred to the extreme Blue right flank and by nightfall of the 8th had already gained considerable ground toward the two crossing points. For the Reds everything therefore depended upon their being able to move forward. The troops they had thrown across were consequently obliged to engage the Blue IIId Reserve Army, which was very shortly afterwards reinforced by the meanwhile arriving corps of the Blue Ist Army. The Reds were confronted by a considerably superior force here. The final result of the two days' fight was that on the evening of the 10th, after suffering heavy losses, the Reds were forced to retreat over the bridge at Worms,[1] which they demolished behind them, and that the Red troops that had crossed at Mannheim were forced back upon their bridge and were barely able to hold the line of the Neckar. The advance of the Red IIId Army had thus been completely checked.

Although the Red commander-in-chief did not as yet consider this failure as decisive, he fully realized that nothing could now change the unfavorable complexion of affairs for the Reds but the corps that had either already crossed the Rhine north of Mayence or were in the act of crossing it. But here, likewise, nothing of note had been achieved. The opposing Landwehr divi-

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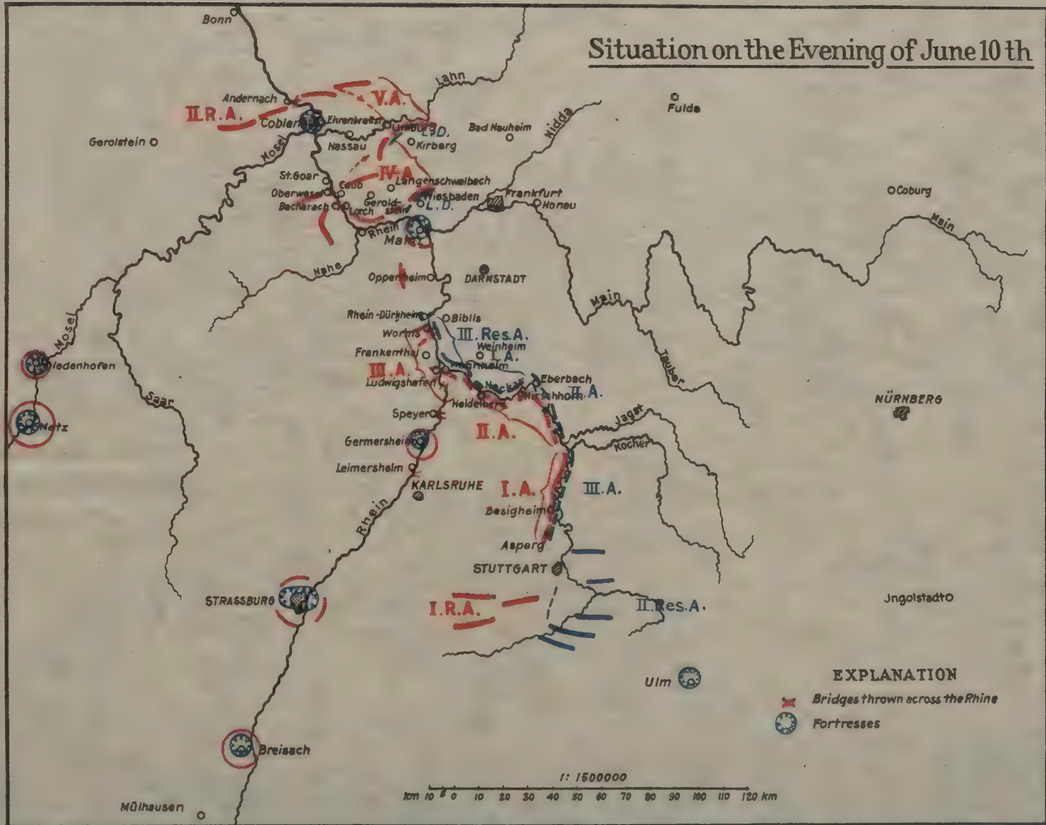
[1]Unfortunately, the Reds had neglected to construct a bridge head to cover the bridge over the Rhine. A strong work of that character could have been built in twenty-four hours and would have ensured an orderly retreat over the bridge, in the event that such a movement became necessary. This neglect is explainable only by the desire to withdraw as few troops as possible from the fighting line.



Central Map Reproduction Plant Engineer School, Washington Barracks, D.C

sions had, indeed, been forced to retire everywhere in an easterly direction, but, according to their instructions, they offered resistance at every turn and retarded the advance of the Red IVth and Vth Armies, which only gradually again were able to deploy on a broad front on the right bank of the Rhine. Thus protracted engagements were fought at Hillscheid (near Coblence), at Gerolstein, at Langenschwalbach, and especially on the Lahn near Limburg. All these fights resulted in the retirement of the Blue Landwehr divisions whenever they found themselves outflanked by superior hostile forces. On the evening of the 10th, two corps of the Red IVth Army confronted two Blue Landwehr divisions at Wiesbaden. On this day, the corps of the Vth Army were as yet unable to gain ground materially beyond the Lahn. The leading corps of the IId Reserve Army had, meanwhile, crossed the bridge at Andernach.

Operations of the Pioneers until June 10th.

The resumption of the advance by the Blues after their protracted retreat, made it plain to anyone that a great blow was impending. Everyone on the Blue side realized that he would have to put all his energy into his work in order that success might be achieved. The pioneers marching with the advance guards were likewise animated by this feeling. The map showed plainly that the army would have to cross a number of streams in its advance, the Tauber, Jagst, Kocher, Neckar, and Rhine. All mounted lieutenants of the pioneer companies accordingly accompanied the independent cavalry in order to send back early information in regard to the nature of the streams to be crossed. Corresponding reports were to be sent back by the pioneer officers of the cavalry divisions. The divisional bridge trains were assigned to the advance guards and each corps bridge train marched directly in rear of the leading division of its corps.[1]

But, for the time being, there was nothing for the pioneers to do, not even at the Kocher where strong hostile forces were first encountered. The Blue IIId Army did, indeed, attack the enemy here with artillery, but made no attempt to push the attack, in order to give the Blue IId Reserve Army time to make its enveloping movement. As the bridges over the Kocher later on fell intact into Blue hands upon the retirement of the Reds, no task worth mentioning developed upon the pioneers, and it was possible to

[1] It was impossible to assign more than a single road to each corps.

hold them in readiness for the problems that would, in all probability, arise at the Neckar.

Neither were the pioneers of the Red Ist and IId Armies specially employed in bridge ocnstruction. From June 9th on, they began to prepare the Neckar bridges for demolition and, on the afternoon of the 10th all bridges over that river from Stuttgart to its mouth were destroyed and all ferries interrupted. Part of the pioneers of the Red IIId Army had accompanied the various corps to the right bank of the Rhine and were employed in building several bridges over the Neckar between Heidelberg and Mannheim, for the purpose of improving the lines of communications of their corps. Later on they participated in the demolition of the Neckar bridges.

The use made of the pioneers of the Red IVth and Vth Armies, subsequent to the crossing of the Rhine, needs closer investigation.

At Andernach, where the Rhine is about 400 m. wide,[1] three corps and two divisional bridge trains had been required for the bridge. The latter appeared to be very much endangered on account of the proximity of the fortress of Coblence. If a large number of heavy Rhine barges or rafts were simultaneously released at the fortress, it was confidently to be expected that they would float down on the broad and swift stream as far as Andernach and would become exceedingly dangerous to the bridge. To frustrate any such enterprise required the establishment of an extensive river guard service, and two divisional bridge trains were accordingly detailed for this duty. This guard service began as far upstream as Engers; a flying bridge was built at Neuwied of boats found in that locality, which, it was believed, would render good service in picking up floating objects; and guns were posted near the various guard detachments for the purpose of sinking vessels floated down stream.—As two additional divisional bridge trains had to remain at the bridge as a reserve for protecting and repairing it, a total of six divisional and three corps bridge trains were required at Andernach; in fine, all the bridge trains of the three corps belonging to the Red Vth Army. As the bridge was in constant use from early morning of the 8th until the evening of the 11th, it was impossible to release a part of the trains by replacing some of the service bridge equipage in

[1]Estimated.

the bridge with improvised material, for any extensive work of that character would have interrupted the passage of troops.—It was not until the Red IId Reserve Army, which followed upon the heels of the Vth Army, arrived at the bridge that two divisional bridge trains could be sent after the line corps that had meanwhile advanced, keeping two bridge trains of the Reserve Army in their stead as a reserve at the bridge.

For the ferry and bridge work executed during the night from the 8th to the 9th of June at Andernach, all the pioneers of the three corps of the Red Vth Army were employed. It is assumed that these comprised nine companies. Two companies, reinforced by a provisional company formed of disabled infantrymen belonging to the XXVth Corps, remained at the completed bridge, and one was charged with guarding the channel above the bridge. Hence, each corps had only two pioneer companies left, which, with exception of those that needed rest, at once rejoined their divisions during the advance. Their first duty consisted of providing a temporary substitute for the absent service bridge equipage. All commanders of pioneer companies were therefore ordered to requisition boards, rope, hasps, spikes, etc., in the larger villages passed by the column and to carry this along on wagons so that at least a small amount of bridge material might be available. It was extremely probable that a considerable demand for such material might arise on the Lahn. As a matter of fact an action was fought there at Limburg and Dietz by three Red corps against three Blue Landwehr divisions, in which, however, the latter did not await the decision but retired as their mission required. The narrow valley of the Lahn, all bridges over which had been destroyed, was occupied by well concealed Blue detachments distributed over a wide front. The attack of the troops advancing frontally over the river had to be made in face of their fire. The weakness of the attached pioneer force threw the Red infantry practically on its own resources. But good use was made of the hasty bridges constructed by the pioneers at the last halt and carried along on wagons.

The Rhine bridges at Bacharach and Oberwesel required a corresponding number of pioneers and bridge trains. But as the river was narrower at these places than at Andernahc, it was practicable to have one or two divisional bridge trains follow each corps.

. . . .

Expedients for Quickly Crossing Streams.[1]

I. FORDING AND SWIMMING.

A. Fording.

If there are no bridges over a stream and neither boats nor ferries are available, fording is the simplest way of getting across. In war, no troops will be water shy, if necessity for crossing exists. The Pioneer Field Manual gives the maximum practicable depth of water at a ford as 1 m. for infantry and 1.3 m. for cavalry. In all probability, infantry will be able to cross even if the water is much deeper. At any rate, reports from the colonies, where fording is still the usual method of crossing on all expeditions, indicate that troops forded streams with the water reaching up to the men's breasts—or a depth of about 1.2 m., and even up to their mouth. But a ford where the depth of water exceeds 1 m., always presents some difficulties. Even with a current of medium velocity, men who can not swim become nervous when the upper portion of their bodies feels the pressure of the current.—There are quite a few examples on record in military history of infantry crossing a stream mounted up behind troopers. Napoleon threw some covering infantry across the Beresina in this manner.

It is usually unnecessary to make any special preparations or to mark the ford; all that one needs to do is to follow the wagon tracks. If new fords are discovered on rivers of some width, a few men, preferably good swimmers who have removed their clothing, should be sent ahead to reconnoiter them. The limits of such new fords should be plainly indicated by poles, ropes fastened to posts, anchored floats, etc. If there are large boulders in the water, they should be removed; if the approaches are bad, they should be repaired. (Par. 29, Pioneer Field Manual.)

It is undesirable to have the men get their clothing wet. If there is ample time, the men should be allowed to undress and to carry their clothing across on their heads or backs. The entire field equipment of an infantryman can be packed in a shelter tent and carried either on the man's head (see Fig. 41) or on his back. (See Fig. 42.) The latter method is used if the ford is shallow. It leaves the man's arms free, which is a considerable advantage if the current is swift.

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[1]According to tests made by German Pioneer Companies.

When properly instructed, untrained men can undress and pack the headload, or unpack it and dress in 8 to 10 minutes. The back load can be packed more quickly.

Streams are forded either on a broad front or, in case the ford is subject to variations in depth, in columns of files or twos, between lines of men posted above and below the ford, to break the current and to save men who lose their footing, respectively. If the men close up too much in crossing in column, the force of the current will be increased. If streams are forded with the aid of cables or coupled poles stretched from bank to bank, the men should cross on the down-stream side of such contrivances. If

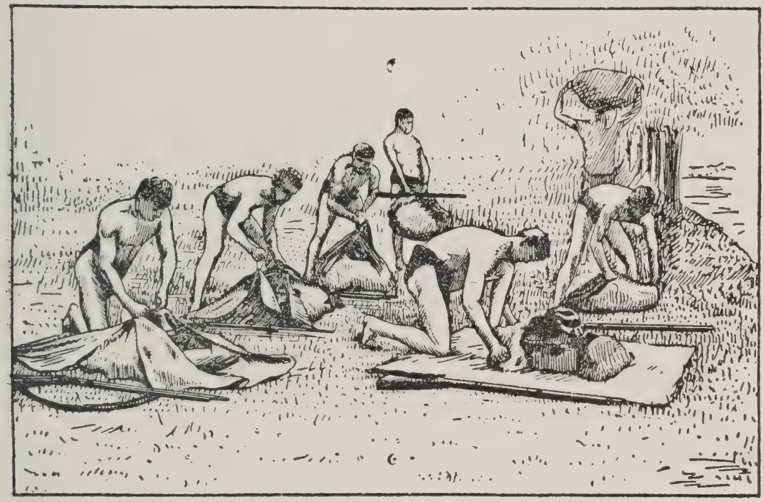


Fig. 41. Packing the head load.

the bottom is rocky or full of sharp stones, the men should wear their barrack shoes.

The cavalry encounters particular difficulties in fording streams, and of all arms is most often called upon to cross them in that manner. In deep streams the unevenness of the river bed, soft bottom, steep banks, nervousness and helplessness of the horses, the weight of the clothing and equipment, may be a great handicap and seriously endanger both trooper and horse. Every ford that is not thoroughly known or that appears unsafe should, as a general rule, be first tested by a good swimmer (undressed) to see whether the water thereat does not exceed the maximum practicable depth of 1.3 m. The direction as well as the limits of the ford should be

indicated by planting lances on the opposite bank, which will assist the troops in keeping the indicated direction. A still better plan consists of posting a few men in prolongation of the ford on the opposite bank with orders to call to the troopers, who ride across in single file (see par. 477, Pioneer Field Manual), when they deviate from the proper direction. If the water at the ford is more than 1.3 m. deep, or if it is shallower but the bottom is soft, fording will be very dangerous or even impossible. Arrangements will then have to be made to swim across. Whether it is a good plan to hitch a lariat to the leading horse so as to enable the following trooper to pull it back in case it loses bottom, will have to be

Fig. 42. Back load.

determined by experiment. In any event, the lariat will have to be kept taut at all times, to prevent the horse from becoming entangled in it. It will frequently be necessary to cut down the banks on both sides of the river and to corduroy them quickly with rushes, brushwood, etc., to make it easier for the horses to enter and to leave the water. Our East-African Colonial troops have had a good deal of experience in fording streams. Their Provisional Field Service Regulations recommend that saddle animals be pulled across narrow, very swift streams, by means of long ropes. These ropes should not, however, be fastened to the halter, but around the horse's body, as his head would otherwise be drawn under during the process of crossing.

If practicable, arrangements should invariably be made in the case of unreliable fords, for safeguarding the troops during the passage. Life-boats and strong cables stretched from bank to bank below the ford are suitable. Poles lashed together by ropes and stretched across the stream in a similar manner will float and are an excellent substitute for the cables mentioned. (See Fig. 44.)

Fig. 43. Fording the Weser.

B. Swimming.

The crossing of streams by swimming, forms an important part of the training of our cavalry. The Pioneer Field Manual devotes

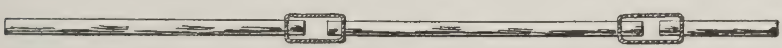


Fig. 44. Coupled poles.

an entire chapter to the subject. (Pars. 425 and 471-476.) Our military literature is likewise replete with suggestions. An essay written by Lieutenant Count von Preysing contains many valuable suggestions in regard to the training of cavalry in swimming and the practical application of swimming in crossing streams.

It is always difficult to transport the equipment across a stream. The horse can not swim with it. Lieutenant Preysing suggests that if a patrol has to cross a stream, it procure a suitable beam, pack the equipment, saddles, etc., in the water-tight feed sacks, and attach these bundles in pairs to the beam. Like the shelter tent bundles, these packed feed sacks will float, and the raft formed by them and the beam can be towed across the stream by a good swimmer. A single trooper can cross in a similar manner.

if he packs his equipment as indicated and either has his horse tow the bundle along as it swims across, or tows it himself with a rope after he has gained the opposite bank. It is desirable, of course, that the horse be trained to swim with the stripped saddle.

The following method of getting saddle, clothing and equipment across is recommended for small patrols (see Fig. 45):

Clothing, saddle pockets, saber boots, mess furniture, and rolled overcoat are wrapped in the saddle blanket and placed in the feed sack. The remaining space is then filled with straw, hay, grass, leaves, rushes, or the like.

Two feed sacks packed in this manner are then fastened together by sticking two lances through the loops on the feed sacks.

The two saddles are laid across the lances and fastened to them by the stirrup straps. The carbines are then attached to the sides

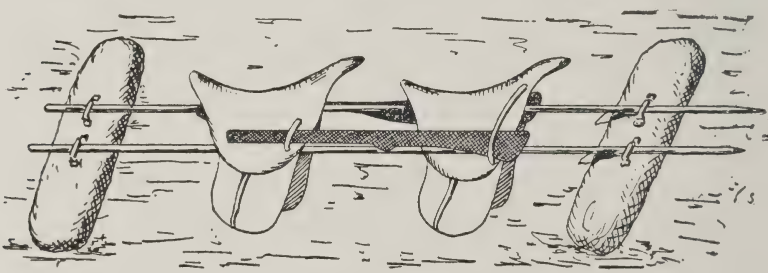


Fig. 45. Raft of cavalry equipment.

of the saddles parallel to the lances. The rafts thus formed are then towed across the stream by a good swimmer.

Good results were obtained with these rafts in crossing streams whose current was slow. In case of swift current, it is advisable to lash two such rafts together by means of a few pieces of timber or lances, so as to prevent their capsizing.

If the cavalry does not employ its service bridge equipage, it can make use of the same expedients, described below, that are used by the infantry.

We might well ask, when will infantry ever have to cross a stream by swimming?

In the first place, patrols may want to cross a stream some distance away from the enemy. In such a case, there will usually be ample time for the men to undress and to transfer their entire

equipment, as well as men who can not swim, to the opposite bank, rafts being used for the purpose in the absence of other contrivances. If there is no need of haste, a small unit of such company may cross in a similar manner.

Besides, it will often be desirable for patrols and other small bodies to withdraw quickly from hostile pursuit during a retreat, when neither boats nor ferries are in readiness for transferring them across the stream. The individual soldier will simply have to swim in such a case to make good his escape. He will, without doubt, quickly remove his boots and even his coat, but endeavor to carry his arms with him. Aids in crossing in such a manner consist either of some substitute for a life preserver, or of floats to which the man can cling and to which he can fasten his weapons and perhaps even a part of his equipment.

Such simple contrivances are still more important when it becomes necessary to cross a stream, even a narrow one, in face of the enemy and under fire. As already stated elsewhere, pontons and hasty bridges are to be utilized when practicable, in such a case. But it is questionable whether one will be able to utilize these in every case, as it will be exceedingly difficult, especially under hostile fire, to carry the pontons and the usually rather heavy hasty bridges to the river. It is therefore doubtful whether one will be able to depend upon them. It would be ideal, indeed, if skirmishers could advance on a broad front to the river and each man could swim across the stream that separates him from the enemy.

It is by no means asking too much of a skirmish line to require it to swim across a narrow stream. The water near the banks of unimproved, narrow water-courses, is usually so shallow as to permit fording for some distance, and it is only in the middle of the channel that swimming will have to be resorted to for a few meters. If the simplest contrivances were available, one should not doubt the feasibility of getting a line of skirmishers across such an obstacle. It would surely be an especially honorable task for a pioneer company, trained as it is in swimming and familiar as it is with the water and with all expedients used on the water to lead the way for the infantry. To have men swim across is also the best preparation that can be made before using hasty bridges, as it enables one quickly to occupy small supporting points on the opposite bank, under whose cover such bridges can be brought to the stream and laid.

Such simple expedients will likewise assist men who, completely undressed anl armed with nothing but light weapons (pistols), or entirely unarmed, swim to the hostile bank for the purpose of reconnoitering preparatory to a general crossing or preparatory to warding off such an enterprise. The same is true of men who have to swim across to do work of one kind or another on the opposite bank—such as measuring the width of the stream, bringing a rope across, etc. The pioneers carry life belts on their wagons for such emergencies.

Fig. 46. Infantryman fully equipped for field service, pulls himself across on coupled poles.

When infantry has to swim across a stream, it can make use of any of the following expedients:

1. Strong cables stretched from bank to bank;
2. Floats for individual men;
3. Light rafts for transporting equipment and arms

1. A cable stretched from bank to bank, or as a substitute, coupled poles (Fig. 44), will enable men who can not swim to cross deep places in a river. A fully clothed man can draw himself

across a stream 60 m. wide, by means of such a cable or pole, in about 1½ minutes (Fig. 46). It is not very easy to stretch the cable across a wider stream than this. It is advisable to have a good swimmer take a small rope, to which the cable is attached, across first, and then have this man pull the cable across. The cable may likewise be fastened to a long coupled pole, which is laid in the water parallel to the bank, and then let the current swing it over to the opposite bank. where the cable end is secured by men that have previously crossed by swimming. (Fig. 47)

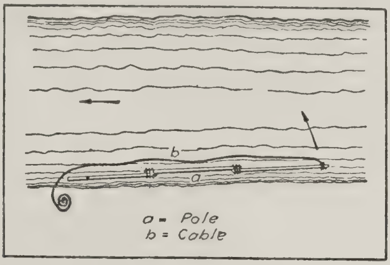


Fig. 47. Method of getting an anchor cable across a stream.

2. *Floats.* But even if such aids are used, it is difficult for men to swim across a stream with all their clothing and equipment. Necessity will usually compel one to use such aids. A patrol that is falling back before the enemy to a river may still escape if it can manage to reach points on the bank where it has hidden simple floats to which the men can cling in swimming the river. If practicable, the men should remove all clothing and equipment that might hamper them in any way. This injunction applies with equal force to men who are required to swim across a stream in making an attack on hostile troops posted on the opposite bank.

Men who possess more than ordinary boldness can swim fully equipped across a stream with nothing to aid them but beams, boards, fascines, etc., but their wet clothing and the weight of the drenched knapsack, overcoats, etc., is so great that considerable performances can not be exacted for any length of time.

In general, ½ cwt. of dry timber will carry a fully clothed man with his rifle and 90 rounds of ammunition. This weight corresponds approximately to a beam 10 × 10 cm. × 2 m.

It is exceedingly dangerous to tie a man to the top of a float, as its buoyancy will tend to turn the man over, thus forcing him

under the water. It is far better for the man simply to cling to the float.

If the rifles get wet when the men swim across—and this is very apt to happen, they should not be used until all water that may have gotten into the barrel has been removed. To what an

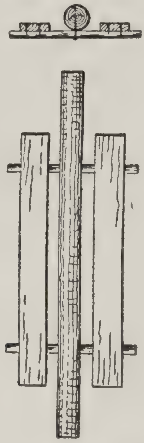


Fig. 48. Simple balk float.

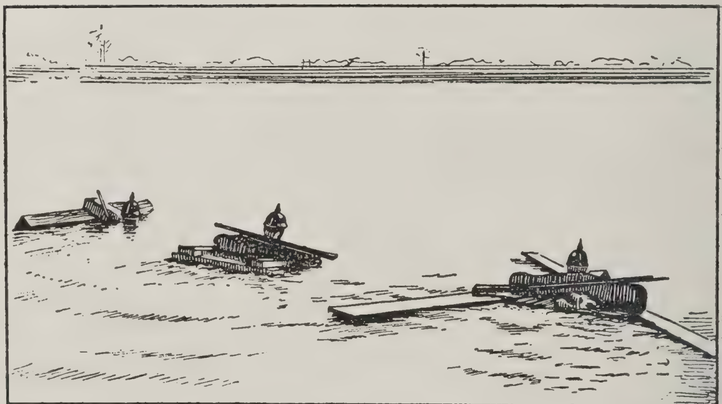


Fig. 49. Simple rafts.

extent the ammunition will stand wetting will have to be determined experimentally. Three or four clips of cartridges can be carried under the helmet, however.

The following contrivances have been found useful as simple floats:

(*a*) Cross pieces are nailed under a beam and boards nailed to them parallel to the beam (Fig. 48). Thongs are then attached to this frame, as also to all the other contrivances to be described later on, by means of which equipments and arms may be fastened to it.

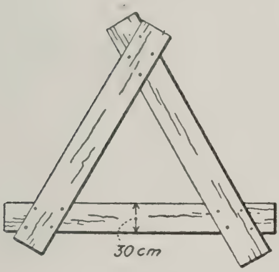


Fig. 50.
Triangular raft of boards.

Fig. 51.
Raft of shelter tent bundles.

(*b*) Triangular or rectangular frames of beams or boards have less buoyancy and are therefore better adapted for men who have

Fig. 52. Skirmishers equipped with "safety" life belts.

removed their clothing before swimming across. (Figs. 49 and 50.) The buoyancy of the triangular float may be increased by fastening a shelter tent bundle underneath, so that knapsack and rifle may be carried there. (Fig. 51.)

(*c*) A simple circular life preserver may be constructed by buttoning three shelter tents together, piling straw thereon, pulling the sides over the top and fastening them and the ends, thus making a ring. Of course, the canvas of the shelter tents must be water-tight. This ring can be still further improved by buttoning three additional shelter tents in a similar manner across the top so as to cover the opening where the lower tents are fastened.

Whether such rings will be suitable for crossing a stream in case of an attack, still needs to be determined. Fig. 52 shows a number of men equipped with the recently tested "Safety" life

Fig. 53. Floating shelter tent bundles.

belts, swimming across a river. The firm that furnished these likewise manufactures floats that enable horses to swim with their complete equipment.

3. *Contrivances for transporting equipment.* If practicable, men who swim unassisted or with the aid of contrivances enumerated under 2, should remove all of their clothing. At most, they should carry nothing but their boots, which they can sling around their necks. If a man carries his knapsack, he will be in imminent danger of drowning, in case he uses one of the floats enumerated and it capsizes on account of the unequal distribution of the load. If time admits, arms and equipment should therefore invariably be transported on separate floats. The simplest and best contriv-

ance for this purpose is that shown in Fig. 77, Pioneer Field Manual. It consists of a shelter tent bundle in which the entire equipment is packed. This bundle will float even if no other material, such as straw, etc., is packed in it. Soaking the canvas in water, will increase its imperviousness. A swimmer can either tow this bundle by a small string, or push it before him, though the latter requires more effort. (Fig. 53.) A larger float is shown in Fig. 78, Pioneer Field Manual.

Another simple contrivance consists of two pieces of timber

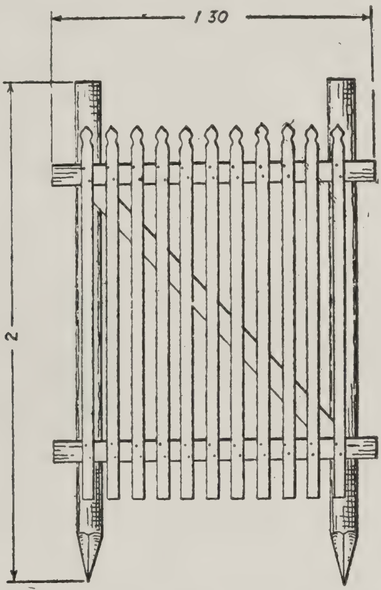


Fig. 54. Raft of posts and picket fence.

over which boards, small poles, or even a section of a strong picket fence are nailed. (Figs. 54 and 55.) This float should not be less than 1 m. wide. The heavier the load it is to carry, the wider the float should be made. Lash ropes should be provided to hold the load in place when the float rocks.

These floats can likewise be used to transport men who can not swim. When used for this purpose, a stout rope should be attached to the float and the loose end carried across the stream by a good swimmer. The man who can not swim can then cling to the float as he is pulled across. Simple rope ferries may also be constructed out of these floats, provided the stream is not too wide.

II. RAFTS.

There are many ways in which local building materials and contrivances may be used to construct rafts of various sorts, on which men can cross a stream instead of fording or swimming it. The *Kriegstechnische Zeitschrift* of 1899, on page 261, *et seq.*, enumerates a large number of rafts that were tested out in the Russian Army, and paragraphs 153-156, Pioneer Field Manual, indicate appropriate methods of construction. Any soldier who is at all practical and resourceful will, in case of necessity, be able to build himself such a raft even if he has not had any special instruction in the subject, provided he is familiar with a few general principles that enter into its construction. If the raft is to be

Fig. 55. Swimmer with a light raft.

built entirely of wood (timbers or boards), its weight, if dry, should equal the weight of the load it is to carry; if the wood is green, more should be used. The buoyancy of barrels, shelter tent bundles, troughs, etc., must be determined by tests in each case. If practicable, rafts should not be less than 2 m. wide, otherwise they will easily capsize. Narrow rafts should be provided with outriggers, as shown in Fig. 81, Pioneer Field Manual. If narrow rafts are used, two men should get on each, one acting as counterweight to the other, who either poles or rows it across. The lower the center of gravity of a raft, the greater its stability. Men should therefore either sit down or kneel on them.

It is not the intention to describe all the contrivances mentioned either in the Pioneer Field Manual or in the *Kriegstechnische Zeitschrift*. Part of them are rather complicated, re-

quire considerable time to construct, and special tools. Only those will therefore be described that can be built in the minimum time out of easily obtainable materials, and whose very simplicity makes them desirable. A barn door nailed on long poles and provided with outriggers, will unquestionably be the most easily and most quickly constructed contrivance of this sort, and, though unwieldy, will be suitable for the use of a few men.

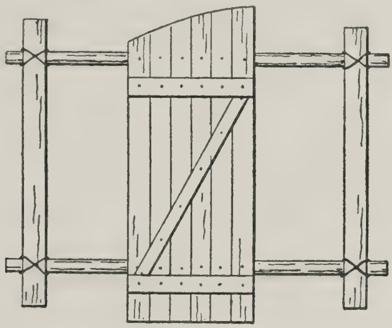


Fig. 56. Barn door raft.

A few simple types of rafts are described on page 263 of the *Kriegstechnische Zeitschrift* of 1899. (See Fig. 57.)

Fig. 58 illustrates the use of a single beam with outriggers 2 m. long.

The raft shown in Fig. 59 is constructed of bundles of brushwood over which boards (or long poles) are lashed. Such a raft

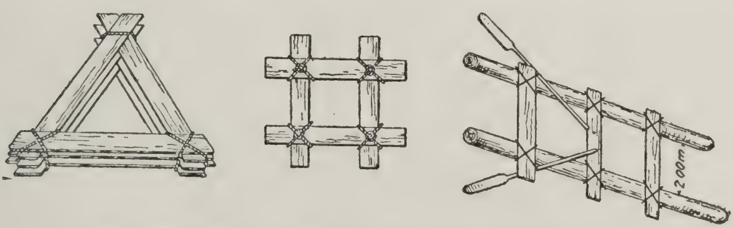


Fig. 57. Simple rafts made of boards and beams.

can be built if one has to cross at a point far removed from habitations and where nothing but standing timber is available.

A similar raft, which has considerable buoyancy, is shown in Fig. 60. It consists of two layers of boards between which straw or, better yet, rushes have been placed. Poles are lashed across the structure so as to hold the two layers of boards and the straw together.

An apparently very useful raft may be made by taking a barrel and fastening it in a triangular frame of boards. (Fig. 61.)

Fig. 58. Beam with outriggers.

Fig. 59. Fascine raft.

It will probably be a good plan to ballast the barrel with rocks to increase its stability, unless the equipment of several men is carried in it.

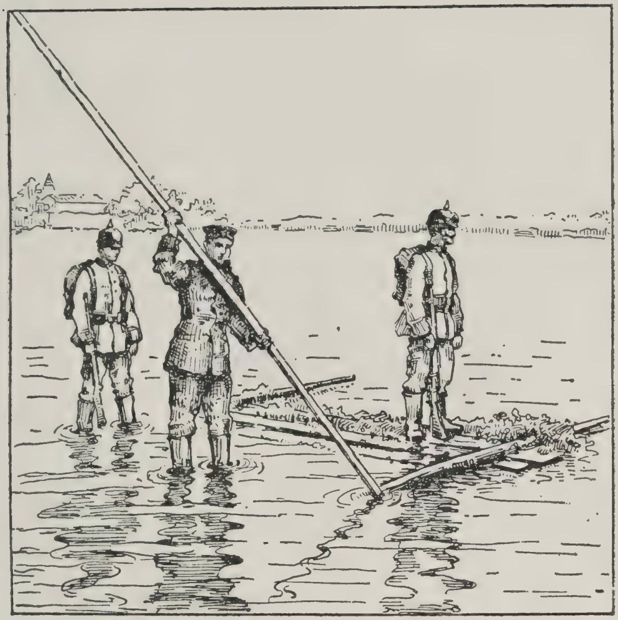


Fig. 60. Straw raft.

Fig. 61. Simple barrel raft.

If they are provided with outriggers, even such unreliable vessels as light skiffs can be used for transporting a large number of men across a stream. (Fig. 62.)

Pars. 148, 158 and 159, Pioneer Field Manual, give sufficient information in regard to the larger rafts that infantry will no doubt be obliged to build in exceptional cases.

Fig. 62. Skiff with outriggers.

OLD AND NEW OPINIONS ABOUT THE VALUE OF PERMANENT AND FORTIFIED POSITIONS.[1]

With regard to the value and utility of permanent forts and fortified positions, their advantages and disadvantages, the nature and method of their employment and defense, their eventual harmfulness, views and opinions have always been somewhat divergent. There has been a time when nothing was deemed more useful and commendable than the construction of a fortress, and even of lines of fortification. Others, however, have thought that all permanent fortifications must be put aside, since they formed an obstacle to movable warfare. The present war appears to confirm the latter view. It would be well to call to mind the opinions of former times, and to verify our own views by means of them.

I.

According to an expression of Napoleon, fortresses are often absolutely necessary, always useful and never harmful. "Every governor or commandant to whom a stronghold has been entrusted should always bear in mind that he has in charge one of the bulkwarks of the realm, or a point of support for the army, and that its surrender at any time, sooner or later may have the most serious effect on the defense of the state, and the welfare of the army." In spite of the offensive tendency of his military leadership, he gave above all his constant attention to fortresses and to fortification, and especially recognized in them the means of making a longer resistance with a smaller or a weaker force, or of making a rallying point for a defeated army.

Radetzky thinks, "A state which does not prolong its existence through the jealousy of its neighbors, must support itself by its own strength gained by an adequate system of defense which will make an impression on its neighbor thirsting for conquest and

[1]From *Schweizerische Zeitschrift für Artillerie und Genie*, June, 1917. Translated from the German by Col. W. R. Livermore, U. S. Army, ret. (I, II, III,) and Maj. Henry Swift, Chaplain, U. S. Army, ret. (IV, V).

make him more peaceful in his disposition, and make it impossible for him to carry out hasty enterprises that are quickly decided. Through a system of defense, the army acquires great mobility in war; and it may protect the country from devastation, and make headway against a much stronger enemy. A properly organized system affords the necessary time for preparation, allows the strength of the standing army in time of peace to be reduced, makes the state conscious of its stability, and gives it confidence and credit both at home and abroad.''

Archduke Charles once wrote, ''If fortresses of the first class (central places) are properly employed, the enemy may operate from any side whatever. They are indispensable for the maintenance of the kingdom. Only after their completion, can we build those of which the influence is limited to single operations and then, according to importance of the operations.''

Another Austrian military writer, Baron v. Leithner also stated, ''So long as the surface of the earth is still mountains and valleys, forests and swamps, and rich and well built land, in contrast with wastes and precipices, as long as all local obstacles are not removed, or, to express it in military terms, so long as territory is such that troops can traverse and maneuver, strong lines of defense and centers of communication (road crossings), finally commercial and political centers, are available; so long will prominent geographic points and lines of strategic importance which by their supposed political significance, shape of boundaries and neutral zones, play a certain part in the plan of operations. To secure such points or lines by permanent fortifications, is a precaution which will bear certain fruit as soon as war breaks out on our own territory. Surely, if one knew beforehand that the campaign could be fought out exclusively in the enemy's land, then there would indeed be no need of permanent fortifications; but who is sure of this? What state can boast of such strength? Such excessive confidence might come at the moment of bitter remorse. Most dangerous, however, were such neglect to a state which from its position might be forced to make front on two sides, and perhaps to hold itself, with a weak force, on the defensive on a front of minor importance, so as to come up so much stronger on the other.''

According to Count Gedern, ''To fortify, is nothing more than by the use of all available natural and artificial obstacles so to

increase the natural power of resistance of troops that, according to the laws of tactics, even a lesser force can utilize every opportunity for the offensive without endangering the possession of the place. Hence, the more inefficient an object is as an obstacle to approach, so much the more should its deficiency be made good by the increase of the living force.

Very rarely, however, in the warfare of today will it be possible to weaken the field army through such strong detachments as the garrisons of the strong points of a wide theater of operations would require; for that would wantonly place in jeopardy the advantage of numerical superiority, and thereby, ones own manner of acting. The latter makes it necessary, on that theater of war which requires preparation, to reduce the number rather than to increase the strength of the fortresses to make oneself secure against the vicissitudes of war. But the strength of a stronghold lies not in its scarp wall alone. It is very essential to maintain the means of defense, protection of the guns and personnel, and the provisions of the fortress.

In laying out fortifications, the military engineer must strive to solve the following problem: To fulfill all the requirements of tactics and strategy by economizing for the state with regard to troops in war and money in peace. This he can accomplish only by the help of his art through the fullest employment and protection of the guns and personnel.

Through fortification of the most important points, will strategy secure to the army or to its parts the necessary quiet in camp, in fortified positions, or on the line of a river; give the troops mobility by making local obstacles passable without loss of time; strengthen by art the natural obstacles which a hostile army must overcome in passing through a territory; secure the supply of all the needs of ones own army, that is, its freedom of movement, so that even in the most unfavorable moment and epoch it can maintain superior strength and seize the initiative where a successful result appears to be secured.

The Russian general, Leer, who has written a very estimable text book of strategy, expresses himself as follows: "Since now in war the fundamental law holds good, to operate always according to circumstances, so it is clear what a high rank among the other branches of the art of war must be taken by the science of fortification, whose principle task is to obtain the greatest advantage from the circumstances.

By the aid of fortification, the defense of natural obstacles (rivers) is possible for hundreds of kilometers, while, without this, they would remain practicable at the most for some two days' marches.

The degree of strategic importance of a fortification depends upon:

(1) Its situation with regard to the line of operations of the aggressor.

(2) The length of the time which it can hold out, and

(3) Its situation in a place advantageous in local, as well as in political, connections.

The problem then, for the recent fortification, is not to lock up the army, and impose upon it a passive roll, but on the other hand, to prepare for it under the walls of the fortification a great and advantageous battlefield.

We conclude this series of quotations with an expression of Moltke's about the demands which must be made upon a great fortress. A great fortress fulfills its requirements when it is extensive enough to enable an enclosed part of an army improvement and recovery, and affords so much means of relief as to make it again serviceable in the field. Large fortresses must also have around them a battlefield prepared by ingenious artificial works, and in case of need, be defended by a proportionately small garrison.

II.

We append here, for further explanation, a series of short sentences of distinguished generals and well known military writers about the same subject as well as about the attack and defense of a fortress, and of a fortified position. In this connection it should be expressly pointed out that in different periods, the taking of a stronghold has constituted the proper and sole object of a campaign. So, especially in the earliest times, not only has the defense of the land been connected with the establishment of fortified cities and castles, but broad areas have been provided with connected walls and ramparts. The greatest and most renowned example of this is the great wall which the emperors of China have drawn around their giant empire. Hereto belong the Median wall which Nebuchadnezzar built for the protection of Mesopotamia from the Euphrates to the Tigres, as well as the Limes and boundary wall

of the Roman Empire, and the "*Letziner*" which our forefathers were wont to erect for the defense of their territory against warlike inroads. In the 17th and 18th centuries a similar system of defense was again employed, as shown by the lines of Weissenburg in Alsace, and it almost looks as if, in the present time, we were again reverting to similar dispositions.

"To place a smaller number of men in such a position that they can resist a larger for a long time, and even fight with them; this is the object of every fortification."—*D'Arcon.*

"As long as one can beat his enemy in the open field he should not resort to besieging fortresses."—*Duke of Marlborough.*

"A man loses his reputation easier by the attempt to take a fortress than by the effort to conquer a province."—*Turenne.*

"The planning of a fortress should always be regulated by local conditions, so that by taking advantage of the ground, the works will be strengthened so much the more.

"Better no fortress than a weak one."—*Frederick the Great.*

"Large fortresses off of the lines of operation are a veritable misfortune for the state and for the army.

"Strong places are a capital support, a superfluity would be harmful."—*Jomini.*

"A small fortress which does not absolutely cover the main entrance to the land deserves little consideration.

"It is a common error of many generals and commanders-in-chief to provide fortresses, which from their location and size might be very efficient, with only the most limited garrisons to hold them and especially with but little cavalry."—*Archduke Charles.*

"Without the help of fortresses, no good campaign can be planned; and without the aid of field fortifications no offensive war can be conducted.

"Positions of the kind which nature offers cannot, without the assistance of art, serve as an adequate barrier for an army against a superior enemy.

"Fortifications are useful in an offensive as well as in a defensive war. They could not indeed take the place of an army; yet they are the only means of stopping a victorious enemy, of checking and harrassing him.

"Fortifications are like guns which alone do not decide anything, but require to be skillfully used and at the proper time."—*Napolean.*

"The greatest bravery is shown in the holding of strong positions; it is the courage to await danger."—*Count St. Quentin.*

"A defensive army without a fortress has a hundred vulnerable points; it is a body without armor."—*Clausewitz.*

"Fortifications seem to have a theoretical as well as a practical effect, like a pistol which is held before an enemy's face, although it is not loaded."—*Baron von Waldstaten.*

"It is the strategic position of a fortification which gives it the greatest importance."—*v. Decker.*

"In defensive relations the most advantageous positions will not be that which cannot be approached but that which is most threatening to the enemy. Such a position will be open rather than covered."—*Paixhans.*

"Strategy determines the site of the fortification. All fortifications derive their significance only from their close connection with the great mobile warfare."—*Willisen.*

"Shelters (for men or material) are named according to their power of resistance;

bombproofs, against a hit from the heaviest mortar and against the blasting effect of a great explosive charge, amounting to 25 kg. of ecrasite.

Shellproofs, against the (shells) of movable seige-mortars (howitzers), as well as against the explosive effects of 7 kg. at most of ecrasiter or similar explosive;

splinterproof, against the balls of all shrapnels."—*Kuk.*

"We should not fail to appreciate that the influence of explosive shells makes the defense of a stronghold harder than it ever was before. Yet there is a great difference between difficulty and impossibility."—*Paul v. Rehm.*

The commandant of a beleaguered place should on principle yield to no reflections which are foreign to his task, he must give up all considerations, have no thought other than to defend his position right or wrong to the last minute, according to the precept and example of all brave men.

In war, the commander of a stronghold is not the judge of the events; he must hold the place to the last hour, and deserves to die if he gives it up an instant before he is forced to do so.

A fortress must hold out until it has no longer either bread or

ammunition, or until the enemy, after the passage of the ditch, has a foothold in the breach, and even then the governor is to blame if he has not constructed a retrenchment to make the breach useless.

The defence of a fortress is not organized until the moment when all military buildings are bombproof.

"At the moment of investment it is too late to erect bombproofs."—*Napoleon.*

It is not the walls which make the fortress strong, but the soldiers who stand behind them—the commandant who has the spirit and the will to defend them."—*v. Brunner.*

III.

Fortifications which are constructed in time of war are called "Field Fortifications." Their construction is demanded by a transient military situation; one has only a limited time at his disposal, in contrast with permanent fortifications, and therefore, is no longer fully at liberty in the choice of his materials, so that the resistance attainable is of course very limited.

Far from the enemy, and therefore with longer time, where fortifications are built at a location previously selected, one will always be in position to call into requisition the workmen and the other resources of the land, so as to provide cover to resist the heaviest guns of the hostile army. These field fortifications take the name of reinforced field fortifications.

Near the enemy where there is often only time to put the troops in position, then the troops alone with their tools are available. Moreover, there is no choice of material, so that they can only be made bulletproof.

Here, fighting fortifications proper are constructed. They are commonly called "Temporary Field Fortifications" or briefly "Temporary Fortifications." These fortifications, which are only to be regarded as makeshifts are always strengthened as soon as an opportunity offers.

Field fortifications not only fulfill their purpose alone; they also serve as the supplement of nearly all permanent fortifications.

With the last paragraph of this quotation, which is taken from an Austrian military writer, the importance of field fortification as such is referred to as a worthless auxiliary of offensive and defensive war and as the inevitable supplement of permanent fortification. Their use is primeval. They are found with the

most primitive people, but also the most scientific military commanders do not disdain to use them.

The Roman legions built, night by night, their entrenched camps by means of field fortifications. Wallenstein and Gustavus Adolphus, near Nuremberg, built their intrenched camps with which for a month they were interlocked. Frederick the Great owed to them his Bunzelwitz. Wellington his lines of Torres Vedras, and thereby both, the possibility to hold out with a smaller number against a larger, and to await a better opportunity to attack. In the American War of Secession, both parties made the most profitable use of field fortification. We remember Vicksburg, with which for a long time the Confederates checked the Union Armies along the Mississippi, and the lines of Petersburg and Richmond in which Lee again and again forced Grant to make a new offensive effort, a situation and a procedure which shows many points of similarity with that on the West Front today, but field fortification found its most astounding use in the war of 1877-78 by the Turks as Osman Pasha established his position at Plevna, and for a long time gave a totally different turn to the war. From Plevna dates the knowledge that a commander-in-chief should no longer take the field without heavy cannon and guns for high angle fire. This has again put the value and the importance of field fortification into the clearest light.

To throw light from all sides a series of quotations follows which illustrate the most diverse views and opinions about the nature and use of Field Fortification:

"In the new war, not permanent fortification alone but also field fortification plays an important part."

"The entrenched camp at Plevna of such remarkable origin became the turning point for an entire war."

"The value of field fortification has increased very much with the efficiency of the weapons now in use against an unsheltered enemy. Military history of recent times has given us in Plevna, a notable example that in some circumstances it is possible to erect field fortifications in view of the enemy which have a power of resistance to the methods of attack of field warfare as to the method of fortress warfare."

Things which the soldier should never be without are: gun, bread, cartridges, entrenching tool.

Artificial protection, made in the right place at the right time offers to the troops and their leaders great and sometimes indispensable service.

A condition is, however, that it only serves the purpose of the command, and does not on the other hand dominate it; but the latter happens when the work is begun before the purpose is definitely ordered fixed. The leaders must have the tactical training to know not only but where and when the entrenching tools are used by the infantry.

The men look for protection; the best soldier does the same.

In fortifying any section one must always keep in view: first, to be able to shoot well, and therefore have a clean field of fire, and then prepare the firing line for the convenient use of weapons; then comes the protection of ones own positions and the improvement of the approaches; last of all the obstacles.

In what relates to the clearing and leveling of the foreground the side ditch of the road in front of Niederwald at Wörth, the field wall at St. Privat and the corn of Chlum should be remembered.

The terrain is never such as troops need in war, there is always some work to be done and in a technical sense something to order. As regards the defenders of a trench they should maintain the greatest serenity, if without it, they should effect it. The men should keep the foreground clearly in view, watching well the projecting angles and gorges. Do not let the second rank fire until the hostile detachments advance.

The largest men in the second rank hold in check the first rank. Arrange a banquette step and a convenient rest for firing. Reconnoitre the foreground, mark distances, have firing trenches dug near the redoubts. Do not let the gorge and flanks be occupied until absolutely necessary.

The most important, but also the most difficult problem in making use of the terrain is occupying the position. The tactician is always the master to whom the Engineer must subordinate himself. "Make thyself complete and if thou can not be complete, then become a willing part of something complete." These words of the poet apply to all auxiliary weapons and organs.

It would be absurd to neglect to build field fortifications where they strengthen a besieging body, covering a position or securing the defense of a narrow pass.

One should perceive in the fortification of a battlefield, not his safety but only a means to the end.

An extended use of the spade, even by itself might make battles obstinate, slow to develop and thus postpone the decision indefinitely; quite otherwise is this case when with such extensive digging great activity is combined.

The spade should not be used under all circumstances, but only when the tactical object requires it.

To-day it is clear that the Engineer must and can relinquish to the tactician a far greater part of the battlefield fortification, that is, all simple work which can be performed with the infantry spade or without special tools, in order to direct his energy to those points which, by their tactical importance, far surpass the others and therefore should be most strongly fortified. Namely, the tactical points of support of the army, the key points of the position.

Even the best covering must be given up without hesitation when ordered, when it affords no field of fire, or when it is proposed to advance.

The secret of victory lies mainly in ability to maneuver and in fire discipline. Let the shelter trenches be ever so convenient, the tactician has to fear their alluring call as much as did William the Conqueror the siren song of his pennants. As the northern hero in wise consideration of the moral factor burnt his ships behind him, so should the tactician shun to expose his troops repeatedly to the cannon-fever which reappears each time they leave the protection of the trenches; since it is a fact well established by experience that troops that have defended and still could long defend a locality have but little inclination for an energetic offensive.

The firing trench is always located where there is the best field of fire, the shelter trench (which is purely non-defensible) is located where there is no field of fire; that is, behind protecting objects.

Rapid comprehension of the terrain and quick survey of the situation of the fight, short deliberation and quick execution, form

the fundamental requisites for the attainment of good results in the domain of the fortification of future battle fields.

In order to use technical troops to best advantage they should not be all split up, but should be thoroughly utilized. If the infantry march by day and establish outposts by night and after watching all night have to fight again, so can the pioneers, and they do, right willingly, march by day and yet work hard by night; the next morning they are not required to fight like infantry.

Pioneers in small detachments reinforce the garrisons of redoubts, but a whole pioneer company should be used for tactical troops in the first line only when there is scarcity of men.

Technical troops as workers always belong in the main fighting line; if on account of the hostile fire they can no longer work there, then they work in a second line.

As is known our army organization of 1874 has taken account of this consideration in the creation of infantry pioneers. They were then abolished in favor of a greater concentration of the Engineer arm, since it was maintained that experiences with this organization proved faulty although in reality, in the maneuvers, it has never been properly tested.

IV.

In addition to technical systems of defence, which up to recent times have consisted of fortified places, intrenched camps and fortresses, General Brialmont (Belgian) has added a new element in his "Fortified Regions." It is no longer a single operative and tactically important point which is to be fortified, but corresponding to the earlier lines of defense, an entire zone, more especially the section embraced or bounded by a stream or river, as, for example, the Maas for Liége and Namur, the Scheldt for Antwerp, the Sereth for Roumania. So it is in a certain sense a going back to the Roman Limes system, or our ancient Litzinen system.

The fortified regions should be so arranged as to obviate the danger of being surrounded, or of offering several vulnerable points, whereby they might be assailed from contiguous territory. They should also, in order to preserve connections and communications, possess ample room for the operation of minor forces, so long as the field is not so extensive as would be required for the handling of an independent army.

To the objections made that flanking operations are largely barred under the conditions incident to fortress and trench warfare, because upon the outbreak of war a multitude of activities and details have to be attended to in and before the place, and that the retirement of troops which have been dispatched from the fortifications for a flanking movement would be difficult, General Brialmont responds: that the first objection disappears as long as the works are amply provided with armored equipments, and the construction attended to of breastworks, which the extensive preparations required in the fiortifications on the outbreak of hostilities would interfere with. To the second he answers that this difficulty would be obviated by the erection of isolated and impregnable forts over the extent of the region defended.

The innate value of the Brialmont system consists in this; that artillery is employed not only in the forts, but also in the many constructions thrown in between them, provided with armored towers having exceedingly strong domes. By means of this it becomes possible to have both artillery and infantry combine in the defence.

The armored tower itself is surrounded by a thick shield of cement, so that of the whole tower the dome alone is visible, presenting a direct target for missiles. The cement, after many experimental tests, has been made more capable of resistance by being mixed with crushed granite, or by being reinforced. The tower itself, or to speak more properly, its dome is movable, so that it is possible to fire in any direction. And so they are able to support other artillery without its being necessary to move the guns to other positions. It likewise affords the simplest means for directing a fire for the purpose of recapturing positions already occupied by the enemy.

In the main the principal considerations in favor of this method of installation of artillery are: that with a diameter of some 6 meters the armored dome presents so slight a mark that, what with the proportion of misses, even the best carrying guns can make but few hits. As far as these are concerned the dome is strong enough to resist the impact of a considerable number of shots. The cement mass that surrounds or encases the tower is so tough that an immense amount of ammunition would be required to make an impression upon it, or finally to demolish it.

As a matter of fact, a series of experimental tests has amply demonstrated these conclusions. For example, in one of these tests it required 85 shots of a well-directed gun to strike the dome 30

times; and, although the balls had a diameter of 15 cm. and a weight of 41 kg., the dome was not in any instance penetrated.

All of our calculations will have to be modified, if success in overpowering such constructions is to be hoped for. Guns will have to be especially designed for such a purpose, and their projectiles loaded with a far more powerful explosive than now exists. Then it might not be necessary to strike the dome of the tower directly: for shots could be employed that would fall against the cement covering or casing. These tearing through the substance of the cement would have to be so destructive in their action that the tower would be deranged in every part, and havoc of all kinds and description be wrought with its appliances. In this way would its guns be rendered unserviceable. Should a projectile strike the dome directly, we could conceive that one would suffice to lay the entire structure in ruins, dome, artillery and the tower itself.

What has been the experience in the present war, and how the Brialmont system has won for itself a good record will be noted further on. At all events, it has become a matter of exact demonstration how very soon every kind of fortification becomes antiquated or obsolete.

V.

There have not been mentioned, and purposely so, along with the hitherto quoted authorities three well-known military writers, who in their works on fortresses and fortified places have treated the subject, often in a very original manner, in all its practical and tactical aspects. These are Golz, Schlichting and Bernhardi. It goes without saying that none of these three could well be passed over, where our intention is to cite the views and opinions of different times and various authorities concerning fortresses, fortified places, and the character of war incident thereto. But since all three are in the truest sense of the word essentially modern, representing among themselves fairly differing points of view, they can scarcely be dismissed with a casual mention or passing reference; but they deserve a more considerable hearing, which will be accorded to them in that which follows.

It is to be particularly noted that neither Golz, Schlichting nor Bernhardi have come from ranks of fortress or technical officers. They have discussed the merits and demerits of fortresses and fortified places entirely from the standpoint of their experience in the war and actual battle. They have not even neglected to discuss the subject from a psychological point of view. On grounds

like these they give a higher and broader exposition; presenting thereby a certain antithesis to the baldly technical grasp which some of the other writers, who have been already quoted, have displayed of the subject.

VON DER GOLZ.

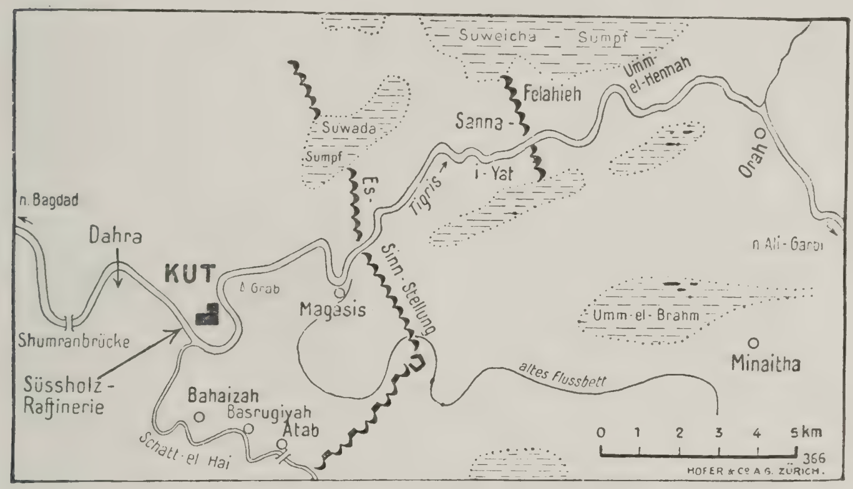
In his much-read work "War and Army Leadership," under the head of "Artificial Land Defences," we read:

The best means of security against fire-attack, next to the skilfully maintained contention of the field of battle, are artificial land defences. They were very heartily recommended after the wars of 1870-71 and 1877-78, where first in the bloody conflicts on French soil the destructive effects of modern ordnance against troops in masses was demonstrated, and later on, after the obstinate resistance made by Turks at Plevna: and an unexpected surrender was made on every hand to the value of intrenchments. Even in an attack were the infantry required and instructed to throw up hastily artificial shelters, and they began to speak jestingly of "offensive spades." Things have greatly changed in these latter times.

It is easy to throw up shelters quickly against a musketry fire that is not too severe; but against artillery projectiles coming from overhead such shelters are ineffective. The advantages one gains in an advance against the enemy by making a cover with his shovel hardly counterbalance the disadvantages caused by the interruption to his own fire. Slight shelters may prove to be prejudicial rather than helpful, because they shield the front without affording any protection against the fire of projectiles. Only strongly built pits or trenches, provided with roofing against the downpour from shrapnel have any real value in the present. Great benefit attaches to the attiring of the men as nearly as possible in clothing the color of the surrounding soil, so that they may be in great measure indiscernible to the enemy. It is of like importance to dress the shelters, either with artificial or with natural covers. The first lesson in these were given us by the Boers in the South-African war.

Works of the kind discussed must prove in the future of the greatest utility. They save the expenditure of strength, and minimize the casualties. They serve to make the men's own fire more deliberate and effective. They give the troops confidence in resisting an attack, while the line of defence is defined and stable; a line which must under all circumstances be held; and the men are practically chained to their post of duty. If the intrenchments are previously plotted out, it is all the better for a passive defence. Faulty intrenchments are really worse than none at all: for their lay is difficult to understand, and one occupies them feeling that he will have to make the best of a bad and unfavorable position. The moral effect of intrenchments on assailants is not to be undervalued; for experience has proved that it is considerable and weighty. This was illustrated in the advance of the victorious German troops on Orleans in 1870, of whose formidable works exaggerated reports were widely circulated.

But von der Golz has not only by word and writing pointed out the advantages that fortified works for land defence might have under certain circumstances, but he has also practically certified his theories in action. As corps commander and as chief inspector general he has worked hard on their material details; so that in maneuvers he has won much honor for himself and for the troops under his direction. He has planned the maneuvers with special reference to the utilization of all the appliances for field defence, and has brought his subordinates into line in carrying out these operations, where once on a time there was no hearty disposition in the German army to employ them.



As it was his good fortune in the present war to be assigned to a high command in the far East, he has there developed the methods of land fortification or intrenchments over an extensive field and in the most ideal manner. In order to frustrate the advance of troops that were undertaking the relief of the British General Townshend's division, invested by the Turks at Kut-el-Amara, he caused the approaches both from the South and from the North to be closed by lines of intrenchments. By these means the hardly to be hoped for capitulation of the Townshend division was brought about: for, as the accompanying sketch shows, two lines of well-constructed and thoroughly equipped trenches from river to marsh barred the approach of the English relief expedition under Aylmer. These two lines were the Sanna-i-Yat and the Es-Sinn entrenchments. They checked and baffled the attempts of the relief columns,

while on account of the failure of provisions and ammunition the beseiged division was forced to surrender (zum Schlagen der Chamade—to beat a chamade or parley for capitulation, to surrender).

These intrenched lines have proved as efficacious as those of earlier seige operations, where lines of contravallation were constructed to protect the beseigers from the attacks in their rear of relief columns; such as Cæsar employed during his masterly seige of Vercingetorix shut up in Alesia. [Comm. Bell. Gall. Liber VII, Cap. 68-88.]

Artificial defences are classified by von der Golz as fortified places, intrenched camps and fortresses. By the first are not to be understood such places as during military operations are simply manned and equipped with matériel for defence, but such as have been with greater prescience prepared previously and built up as for defence, as well as such as possess a greater degree of natural strength.

"We require," he says, "while not unprovided with a further accession of troops, to be employed for a possible offensive, that the place should be furnished at least with a sufficiently powerful armament of heavy artillery."

Fortified places should either have their front, along with their flanks strongly protected, so that a comparitively small force could withstand the attacks and operations of a hostile investment, or it might be arranged that only a portion of the front be fortified, in order that the main portion of the forces might be free to present a more vigorous defence at other points.

Historical examples of the first are furnished by military writers in, for instance, Wellington's lines of Torres Vedras, in the Danish lines for the protection of northern Schleswig and Jutland, in the Czataldscha lines covering Constantinople, and in the strong fortifications that protect the French frontier. In 1860, Gaeta[1] played in a small way a similar rôle. The American Civil War gives us several examples of the kind, notably at Vicksburg and at Harrisons Landing on the Peninsula.

The second class of fortified places have been up to the present predominantly tactical in character. The security of the wings is always a serious problem, and the intrenched line covers only a portion of the front, just where it is weakest in troops. Its flanking must always be apprehended and prepared against, and a field for battle near to the place is to be chosen and laid out from the start (von Hause aus), where the calculation is to employ the balance of the troops successfully in the defence.

[1] [In Campania, the last stand of Francis II against united Italy.—S.]

More lightly constructed, but still permanent in their character, are fortified positions for the protection of railroads, for the security of exposed stretches of frontier, and for the defence of plants that provide the necessary war materiel. While capable of offering but a temporary resistance, they should be constructed on the lines of regular fortifications; and this should be done in time of peace, for it is to be feared that when war actually begins time would fail for the purpose.

The intrenched camp serves as a protection in and for the rear. It is a complete enclosure, and presents a front on every side. Still it in so far resembles a fortified place, that it needs an army to serve its purpose.

Without this it is worthless, as was evidenced by the Conlie Camp at Le Mans in 1876.[1]

An intrenched camp should serve an army as a point of support, as well as a haven of refuge. It will be of use for keeping up connections, and for furnishing a base of retreat. The Turkish intrenched camp of Plevna, although constructed under the observation of their adversaries, and of the simplest and crudest appliances, served as time went on for all these purposes.

The intrenched camp may also be employed as a point of support for a wing to rest upon while the other troops maneuver; or it may be contiguous to some vital point, such as the crossing of a large stream, to prevent its being occupied by the enemy during a brief absence of the main body. In addition the intrenched camp may serve the purpose of a provisional or auxiliary fortress, which, while not so strongly constructed, may prove of considerable value. Dresden played such a part in 1813, and was employed again in the same manner by the Prussians in the campaign of 1866.

The fortress is more independent than the camp. It is more strongly built, and can not be taken by the ordinary field appliances. It is possessed of everything that is necessary for self-sustenance, and for maintaining its garrison; and it is able to hold its own without the support of an army.

From this it appears that, next to fortified places, fortresses are of advantage where it is desirable to hold a position back of the theater of operations, there existing no necessity for maintaining a separate army.

The earlier Turkish empire had, for example, two such assailable districts: Epirus on the Greek coast, and the Albanian basin on that of Montenegro. If a foreign fleet should dominate the sea, on the land side it was only with the greatest difficulty that troops could gain an entrance; and once there corralled they could not contribute in the slightest degree toward the general defence of their country. Here existed good reasons for fortifying the principal cities of each land stretch, Janina and Scutari, so that they could always be held by the available forces of the place and vicinity.

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[1] [Does not writer mean the early winter of 1871, when on January 10-12 Chanzy was defeated by Prince Frederick Charles?—S.]

Königsberg in East Prussia was obliged under circumstances to play a similar rôle in an obstinate and long continued struggle, where the warring powers of Germany maintained their claims in several warlike operations, contending for the possession of the country on the other side of the Vistula.

Some very original observations are made by von der Golz on river fortification; that is, constructed for places lying on streams, and for ports of landing.

First of all the defence of a river line is mainly concerned with its front only: for the defence is ordinarily free from the apprehension that in case of a defeat he is thereby beaten on the river and at its bridge-crossings, while the enemy has his way clear for pressing on. As soon as an action has taken an unfavorable turn, the defender can shelter himself behind the works of a fortified place, he can in safety attain the other shore, and there make his dispositions for a renewed stand. Here is where the fortress will serve as a point for one of his flanks to rest upon, as may be recalled in the operations about Metz. The assailing force is handicapped in that while it is figuring on making a crossing, it must at the same time be on its guard against what the fortress may effect, whence there may be expected at any time a counter-offensive on the part of its defenders.

We have not as yet in our country (that is, Switzerland) any river fortresses; still it would be possible to devise something of the kind, even though it was only of a provisional character. Defensible points exist, and in due time they could be satisfactorily strengthened on the lines of the system of regional fortification. On this subject von der Golz expresses an opinion in his no less well known work, "The People in Arms," where he says:

Armed strongholds would be of especial value along the courses of the great rivers. Field Marshal von Moltke, in an article written in 1868, states that the Rhine as a line of defence could, with its fortresses and a contingent of a hundred thousand men, maintain itself against any invading force whatever for a period of from four to six weeks. Whichever party has control of the fortifications along a stream is master of both banks, and can on either side of the same strike a crushing blow against the divided forces of the enemy. This will cause the invader to hesitate in attempting to pass over the river, as he would fear an attack while he was in the act of crossing. Napoleon severely censured Viceroy Eugene, because in the retreat of 1813 he did not make use of the minor fortress of Custrin in this manner for the defence of the Oder. "If you had pushed forward to Custrin," so does he write to the Viceroy, "instead of falling back on Frankfort, the enemy would have thought twice before he had ventured on to the left bank. You would at the least have saved twenty days thereby."

There follow remarks on the general use of fortresses, giving two instances, which indeed throw a vivid light on the disadvan-

tages that appear. These are Kars in Armenia, and the other instance has to do with Metz and Plevna.

Very skilful was the use made of Kars by Achmed Mokthar Pasha in the beginning of his campaign against the Russians in the early part of the Winter of 1877.

He marched back of this fortress in order to involve the enemy in its investment, and to give himself time to recover from the losses he had suffered. In this way he secured for himself the delay that he needed in order to throw his for the time being shattered forces into a strong and commanding position between the advancing columns of the Russians. He first drove back one body of the enemy that was threatening the rear of his right wing, and then inflicted on their weakened center, hastening from Kars to relieve the others, a crushing blow inflicting upon them approximately as great losses. Then pushing on with his victorious army he relieved the fortress, using it later as a prop for his flank. At that time Kars was in no ways prepared for an obstinate defense against a well-organized and conducted siege. It was equipped only to sustain itself under ordinary conditions. Not every general, however, but only a skilful and resourceful leader would have known how to gain such advantages from the contiguity of a fortified position.

The proximity of Metz made it possible for the Army of the Rhine, after the defeat of Spichern, to hold itself without any great danger under the shelter of that citadel. There lacked only persistence to have gained other and greater advantages from this contiguity. Metz permitted Marshal Bazaine to accept unhesitatingly the gage of battle on August the 14th. It made it possible for him to draw back the army over the Moselle, although the Germans had reached the river-line before he did. It furnished him a support for his left wing on the 16th and 18th of August, and it prevented the pursuit of his beaten right wing after the battle of St. Privat.

It goes without saying that Osman Pasha's attenuated forces would not have been able to play the part they actually did at Plevna, if it had not been for the skillfully but hastily thrown up works there constructed. But in each instance, both at Metz and Plevna, we find that the crucial moment, so hard to be seized, for the abandonment of the fortifications was eventually neglected and the opportunity lost by the commanders of these positions, and what might have been the intermediary means of their deliverance became finally that of their destruction.

In the already mentioned contentions which have arisen among us in reference to the several systems of fortification, it has been inevitable that the question of fortifying principal or capital cities should have come to the fore. Over the matter there has been a competition between Bern and Zurich, the first holding one opinion, the second-named another on political and strategical grounds. Finally Lucerne came into the field, claiming on various grounds that it held the first rank. It is therefore not uninteresting to read

what von der Golz has to say about the fortification of capitals and principal cities:

> Capitals and chief cities, which in their districts for one and another reason occupy an important position, and which by their location are exposed to the danger of attack and capture, should be fortified. Constantinople, Copenhagen, Lisbon even, come under this category. An enemy who has won the supremacy of the sea might easily capture such places by a sudden descent, thereby crippling the entire machinery of government.
>
> Political considerations become here of the first importance. The fortified capital or metropolis may also become the kernel or determining element of the entire system of the defence of the country. And here we should not fail to recognize a possible weakness or detriment in that so great a fortified plant might constitute a serious drain on the forces needed for service in the field. It will not only support, but may at the same time fetter these, holding back a considerable portion of their strength for garrison duties. These exists right here the danger of the beleaguerment and surrender of a considerable proportion of the effective strength of the army.
>
> This consideration becomes more serious, the more important the fortified place is in comparison with the strength of the army in the field. Bucharest could well be more an element of disaster to Rumania than Paris to France.

It is well known that in the present war Bucharest has avoided this fate; for in good season it was abandoned as a fortress, and all its available war matériel and ordnance was taken to the Sereth line, while that which could not be moved on account of its weight was rendered unserviceable.

Over the already mentioned, much debated, and unquestionably historically correct work, "Attractive Power or Magnetism of Fortresses," von der Golz delivers himself in the following remarks:

> It is only natural that the proximity of a sheltering fortress must, in a difficult strait, exercise a strong influence upon an army; and it is very much easier to conduct troops back of stone walls and heavy guns than to lead them forth again from this safe asylum. The supposed necessity for a support or covering for the troops during operations hides many a rock on which the command may be shattered. This has inspired a modern writer to make of it an allegory, likening the fortress to a Sphinx, which dooms to destruction all those who fail to answer her riddle.
>
> Herein do we find a weak spot in the last form of employment to which a great entrenched or fortified camp may be put: namely, when an army is beaten in the field, or is hardly pressed, that in such a place it can find a refuge, where it may recuperate, recover its strength, be supplied with all necessaries, so that it may become fit to resume operations in the open. The whole idea is essentially theoretical, as actual experience in war has demonstrated. Metz is a great warning example against such an idea.

Only where a support from without is to be expected with certainty, and is near at hand, and where it is the purpose to save a weaker force from destruction by the enemy, so that it may be sheltered until such time as it can unite with other bodies for combined operations, can there be an exception worth consideration. Prague rendered the Austrians such service in 1757, and so did Ladysmith, Kimberley and Mafeking to the English in the Boer war.

He makes the following comment on Brailmont's "Fortified Regions":

They should consist of a large fortified camp and a number of auxiliary points in its vicinity, in some strategically important section constituting a triangle or a quadrilateral, whose sides would extend at the most some 25 or 30 km. Within the same the army in need of relief may find shelter, like a spider lurking in the center of its web, ready to spring forth when the occasion arises for action. As an example may be instanced the employment of such quadrilaterals in the wars of Venetia and Bulgaria, although there lacked in their construction in either case the touch of a master-hand. There was in the first the need of still another point of support, while the other required a central fortified camp, to which the four older places could have been subsidiary.

He thus expresses his judgment on the whole proposition:

The complete investment or surrounding of a fortified region is rendered impossible by its very extent. The army that occupies it is freer in its movements than if it were confined within an armed or fortified place. Its return after a sally can not well be prevented. The enemy may bring strong pressure to bear at some point, but in such a case the army of defence, supported by its intrenched base, is able to deliver a crushing blow where the other has somewhat weakened his lines, as in 1866 Archduke Albert struck the Italians. Should the enemy break up into separate groups, then a more favorable opportunity is given the other side for an advantageous engagement than if it were in the open country; just as was the case at Custozza. So a fortified region possesses indisputable advantages over isolated strongholds or a chain of frontier forts.

But if General Brialmont figures on a systematic fortifying of all regions after this manner, and to block all probable lines of approach which the enemy might take through the fortified regions, or to threaten them from the sides, thus covering the map of Ceneral Europe with a network of fortress constellations, the thing goes too far. It is too vast. If all of these places should be constructed after the latest and most approved methods, and equipped with the best armament, the cost would be prohibitive. It would also become necessary to make drafts on the armies that since the beginning of the war have been holding a position of the enemy country, thus weakening the armies in the field, which thing might materially affect the success of the forces upon which the Fatherland depends.

The disposition to increase overmuch the fortification of a country springs from a feeling of weakness. A people, in whom the offensive

spirit is prominent, will only depend upon such means of protection in a measure. If safety is sought behind walls and intrenchments it is an indication of lack of confidence in one's own inherent strength. There will be the tendency more and more to confine oneself to the defensive, whose end is nevertheless ultimate defeat, no matter how long it may be delayed.

In the year 1889 the German engineer, Schumann, publicly advocated the substitution of lighter constructions for the monumental fortress masses of stone, cement and steel. His idea was not to seek protection against the destructive effects of gun-fire by an ever increasing strength of the shield, but by diminishing the size of the target, by concealing, depressing, minimizing the chances of its being struck. His ideas are on the same lines as have been practically carried out in the Brialmont system. Thus originated the Schumann gun carriages, which were armored, first for heavy, then for lighter pieces, and finally there was designed portable shields for machine-guns in the trenches.

Too small to be struck ordinarily, unless by accident, by projectiles from big guns, they are impervious against field artillery and rifle fire. Grouped into organized batteries, and supported by several heavy pieces, they constitute so strong a line that any attempt to take by a charge will rarely prove successful, and then only at the expense of heavy losses. A regular attack must be as against a fortification, although the operations may be of briefer duration; and the outfit will generally serve its purpose. The security of this method has already been tested in several engagements. It is easy to blend the outlines with features of the ground. Of course they will be discernible, even more than one might imagine, from a considerable distance; but it is easy to disguise them. If one has the guns with their steel casings on hand, it is possible in a few weeks to set up a fairly strong defensive position, which with a small force may put up a stout defence against superior numbers of the enemy. Finally, if the issue is successful, it is competent to reestablish the same at some other point.

These movable Schumann protecting towers have also come in great favor with us in Switzerland, their employment in our system of land defence being strongly advocated. For instance, they would serve the purpose in case it were necessary to fortify Lucerne. It would turn the place into another Plevna. It is true that there has been a revulsion and, in view of the enormous expense involved, the idea has been dropped, and our main dependence has been placed, as heretofore, in our field army.

Von der Golz is in favor of the Schumann system, as appears in the following passage:

To possess the means for extending fortified lines, as it were—extemporizing them, is a valuable asset. It serves for attack as well as for defence. How glad Napoleon would have been in 1812, had he been able to turn Smolensk into a great fortified camp! For the security of the base of supplies in the rear of the army in the enemy's country such a mobile system is peculiarly applicable. It only requires for the purpose the necessary number of lightly armored rapid-fire guns, portable and transportable, these to be stored at the various stations.

Extended positions, such as the Danewerk of former times, lend themselves readily to such a system. The first example on a large scale is found in Roumania between the Danube and the Carpathians on the Golatz-Fokschani line. It also will serve for wide breaks between advanced works, as also to cover the exit of an army that is enclosed with intrenchments around its entire extent. These armored carriages are also useful in defending narrows, gaps, gorges of every kind. They find a proper place also in counter-approaches, pushed out by the defence from fortifications to frustrate the attempts of the engineers of the enemy. Experiments have been made in maneuvers to employ these movable armored pieces in the establishment of secure supporting points. There would be many opportunities for their profitable utilization in field service: however, their lack of mobility, or rather their slight degree, militates against such use in operations, unless by chance a peculiarly favorable opportunity offers.

In summing up he says:

After all that has been said of this system, which is as yet in an inchoative stage and open to improvement, the lessons gained from our experience of war must assure us that we cannot deny the place held by the fortified town or the civic rights involved. There must be room both for the army and for the fortress, the one complementary of the other. It is not for either to determine the fate of the other.

This portion may properly terminate with some brief and epigrammatic extracts culled from different parts of the writings of the Field Marshal and, whatever may be said for or against fortresses and fortified places, be exhibited in tersest and most illuminating form:

Fortifications are tactics graven in stone.

Fortresses shelter the troops that occupy them; but they chain them likewise to the spot.

It is easy to throw an army behind walls, but it is difficult afterwards to release them: there comes the need then of powerful help from without to lend them a helping hand.

In all relations between fortresses and an army in the field, the latter should hold it as an immutable law never to allow itself to be

immured within the stronghold. Even to pass through such a place has its perils. It is always better to use the fortress only as a point of support, the army thus preserving in full its freedom of action.

Great armies, which take shelter in a fortified place after the loss of a battle, as the histories of Alesia (Cæsar, Comma. Bell. Gall. Lib. VII, Cap. 68, etc.), and of Metz demonstrate, are nearly always doomed.

In earlier days fortresses possess great value as bases of supply, where armies were dependent on one or only a few depots. Had Naumberg, in 1806, been a fortress, its investment by Napoleon would not have had such disastrous consequences for the Prussian army of the Saal as it did. Their only main depot was thereby lost. Today, where the whole country back of the armies is a source of supply of matériel of every kind, and is traversed by railroads with their capacity of rapid transportation to one and another point, the defence or even the loss of such a magazine would not be a matter of such paramount importance. The rôle, then, of a fortress as a base has its limitations. It will only be of consequence where the approaches, or field of operations, are confined within very narrow limits: for example, if a naval power has a fortified port on a foreign coast, furnishing the only available point of disembarkation to an invading force.

That fortresses are specially advantageous points from which to assume an offensive is likewise difficult to prove. The works themselves do not contribute to flexibility of movement. It is better for an army to attack in the open. If it should happen to be over a narrow or confined stretch, such as a depression between mountains, then naturally it would be a good thing to strengthen the gap or pass by fortifications. Thus the French have established works in a position of prime importance in the famous gap of Belfort. In well settled and cultivated regions (Kulturland), with abundance of roads and avenues of travel and transportation, such blockades present their difficulties. A few good forts might well suffice for all purposes, thus saving the establishment of fortified camps. Belfort in its present state is on the whole better adapted for the defensive; and the question of its retention or abandonment has been moot since 1871.

During the war of 1870-71 the fortress of Langres lay back of the German lines, garrisoned by 17,000 men. It was never threatened or approached by more than half that number of troops, and yet, although within a few miles of two armies, it never took any serious initiative or risks. Of course, there was a good deal said and written at the time, it being claimed that it served as a point of unrest or menace; but as a matter of fact the proof of this lay rather in the apprehension felt, than in what it actually accomplished.

(*To be continued.*)

MINE RESCUE WORK.

By

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MINE RESCUE WORK.

Mine Rescue Work as applied to military mining embraces the use of oxygen breathing apparatus and reviving apparatus for the purpose of rescuing men who have been gassed by Carbon Monoxide and other poisonous gases encountered under war conditions. An intelligent study and application of the methods suggested will obviate many of the accidents caused through gas poisoning, and will indicate the proper First Aid treatment in the trenches. Too much emphasis cannot be placed on the importance of thorough training and care in the use of this rescue apparatus. Numerous lives have been sacrificed on account of lack of apparatus or inexperience in its use.

Directly after an explosion has occurred, it is the duty of an officer to go below in oxygen breathing apparatus and investigate the extent of the damage done. He usually carries with him a canary. These canaries (in common with white mice) are very susceptible to poisonous gas, and, in its presence, topple from their perches and fall dead; thus the man is warned that, unless in oxygen apparatus, it is fatal to remain or proceed further.

Great care must be exercised in allowing men to return to work below after a blow. They should be provided with canaries and instructed to watch them carefully.

Carbon Monoxide and Carbon Dioxide are developed by the detonation of high explosives and the presence of the former, even in the most minute quantities, is sufficient to cause death in a very short time. Incomplete detonation naturally results in an increase of CO. It cannot be too strongly insisted upon that the presence of CO in the atmosphere has no effect on the flame of a naked light; if anything, candles burn more clearly in the presence of CO.

In most of the Army Mine Schools just behind the British lines in France are included courses in Mine Rescue work. The lectures and practice in wearing the apparatus are dove-tailed in with other lectures to Engineer officers and men. It is customary to give all

officers and as large a number as possible of the noncommissioned officers and men this course in Mine Rescue work. The "Proto" Oxygen apparatus is employed, together with a smaller type called the "Salvus." In addition to this, instruction is given in the use below and above ground of various types of reviving apparatus, such as the "Novita," etc.

The "Proto" apparatus, which weighs about 35 pounds, is only employed where the investigation is likely to take longer than 20 minutes; and the "Salvus," which contains enough to supply the wearer for 30 minutes, is used instead. We will use both the "Proto" apparatus and the "Gibbs." It is planned to supply the "Gibbs" large apparatus, that is, an apparatus capable of supplying oxygen for a couple of hours as in the case of the "Proto," and the smaller "Gibbs" probably supplying three-fourths of an hour's oxygen supply. The "Proto" apparatus has proved particularly successful in the war, and men very shortly acquire considerable confidence in its use. It is likely, though, that for most investigations, the use of the "Salvus" or smaller "Gibbs" sets will be common, since 15 or 20 minutes is usually long enough for most of them.

A systematic test of "Proto" which may be of use for reference:

1. Test Oxygen. Contents and pressure.
2. Test Caustic Soda (NaOH).
3. Missing parts:
   Goggles, Noseclips, Spanner, Check Chain.
4. Air-tightness:
   Cigarette test for High Pressure;
   Breathing bag for Low Pressure.
5. Test Valves:
   Exhaling, Inhaling, Relief Valve, and rate of flow of oxygen through reducing valve.
6. Pressure Gauge.

After turning off main gauge, try pressure gauge for Oxygen. For the Salvus test carefully the two nuts on each side of cylinder and then satisfy yourself as to all other connections. Also test rate of flow of oxygen through reducing valve.

Mine Rescue shelters or dugouts are located within convenient reach of mine shafts in the front trenches; and these are stocked with a sufficient number of apparatus hung up ready to wear at a moment's notice. "Proto men," as they are called by the British, men who are experienced in the use and care of the rescue appa-

ratus, relieve each other on duty in these rescue shelters, and when men are gassed as the result of a "blow" or by encountering poisonous gas in the galleries, they immediately go below to bring them out and apply resuscitory treatment. (Experience shows that chalk in particular retains the poisonous gases developed by the explosions, and frequently men are gassed below when working through strata which has been previously blown.) When a gallery has been broken into, small mobile charges, usually under 50 pounds, are often used in hasty attacks, and on these and similar occasions the use of breathing apparatus is necessary afterwards to investigate the damage done.

The following proportions of CO developed may be of interest:

	Exploding, per cent	Burning per cent
Guncotton (wet)	28	48
Guncotton (dry)	40	54
Ammonal	25	40
Gelignite	7	30
Blastine	10 to 12	

"THE FLEUSS OR PROTO APPARATUS.[1]"

The Fleuss or Proto apparatus is decidedly the simplest that has yet been invented. The cylinders of compressed oxygen are slung over the small of the back. Closely connected with them is a reducing valve which is set to afford a definite flow of oxygen, usually about 1800 c.c. per minute. There is also a by-pass, controlled by a separate stop-cock, by which the large rubber breathing bag can be rapidly inflated. The oxygen supply both from the reducing valve and the by-pass flows through a tube under the wearer's arm to the breathing bag, which is suspended over the chest and abdomen. This bag has a partition of heavy sheet rubber extending down from the top to within a short distance of the bottom. Flexible rubber tubes connected with the upper corners of the bag lead to a mouthpiece. A nose clip compresses the nostrils and the wearer breathes wholly through the mouth. Valves are placed at the junctions of the tubes with the bag so that he inhales from the bag on one side of the partition and exhales into the other side. Four to six pounds of caustic soda in sticks is placed

[1]From "Technical Paper, Number 82, of the U. S. Bureau of Mines," entitled "Oxygen Mine Rescue Apparatus and Physiological Effects On Users."

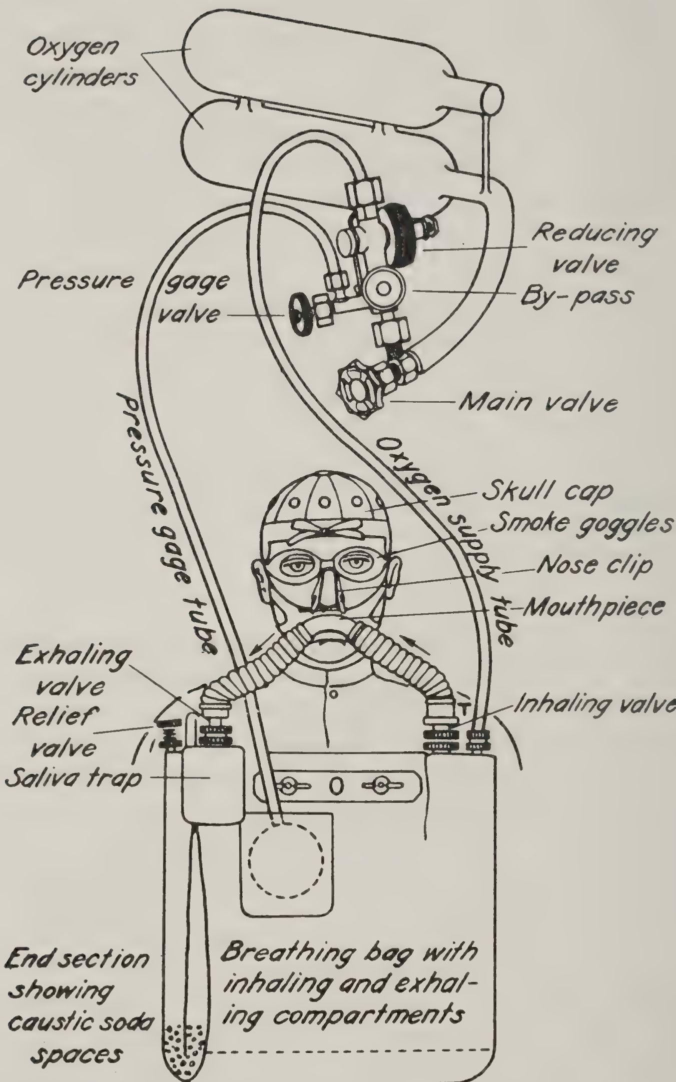


Fig. *A*. Circulating System of Fleuss, or Proto, Apparatus.

in the rubber bag. When the apparatus is put on, the bag is inflated with oxygen by means of the by-pass. Thereafter the wearer's breath passes into the bag and down through the caustic soda, and is reinhaled from the other side of the partition. Carbon dioxide is thus absorbed, while oxygen is continually flowing in from the reducing valve. The efficiency of absorption may be increased by shaking the bag and thus knocking the accumulated carbonate off the sticks of sodium hydrate, so as to present a fresh surface for absorption. Numerous analyses of the air from this form of apparatus have shown that except when the wearer is resting the bag should be shaken frequently; otherwise, the carbon dioxide accumulates and makes breathing uncomfortable.

THE GIBBS APPARATUS.

The apparatus devised for the Bureau of Mines by Mr. Gibbs differs from the foregoing particularly in respect to three features:

(1) The control of the oxygen supply.
(2) The arrangement of the alkaline absorbent, and
(3) The prevention of excessive heat from the reaction between the carbon dioxide exhaled and the alkali. (See Figure B.)

The rate of oxygen supply is automatic. The wearer of the apparatus breathes into and from a small bellows. When the bellows is sucked flat a valve is opened, which allows oxygen to feed in rapidly from the compression tank through a reducing valve of improved design. Thus, the rate of oxygen supply is automatically controlled by the wearer's breathing, and, as tests have shown, adjusts itself with equal readiness and adaptability to his needs during rest, when the consumption per minute is only 300 or 400 c. c., and during vigorous exertion, when it is between 2,000 and 3,000 c. c. per minute.

The movement of air in this apparatus depends on the breathing, as in the Fleuss or Proto type, and not on an injector, as in the Draeger and Westfalia types. From the mouthpiece the expired air passes through a cartridge somewhat similar to that of the Draeger and the Westfalia; the sodium hydroxide is, however, cast in plates upon wire gauze. Trial has been made—instead of fused alkali, as in the Fleuss, Draeger and Westfalia types—of alkali containing a small percentage of water of crystallization, approximately 19 per cent, or one molecule of water to two of sodium

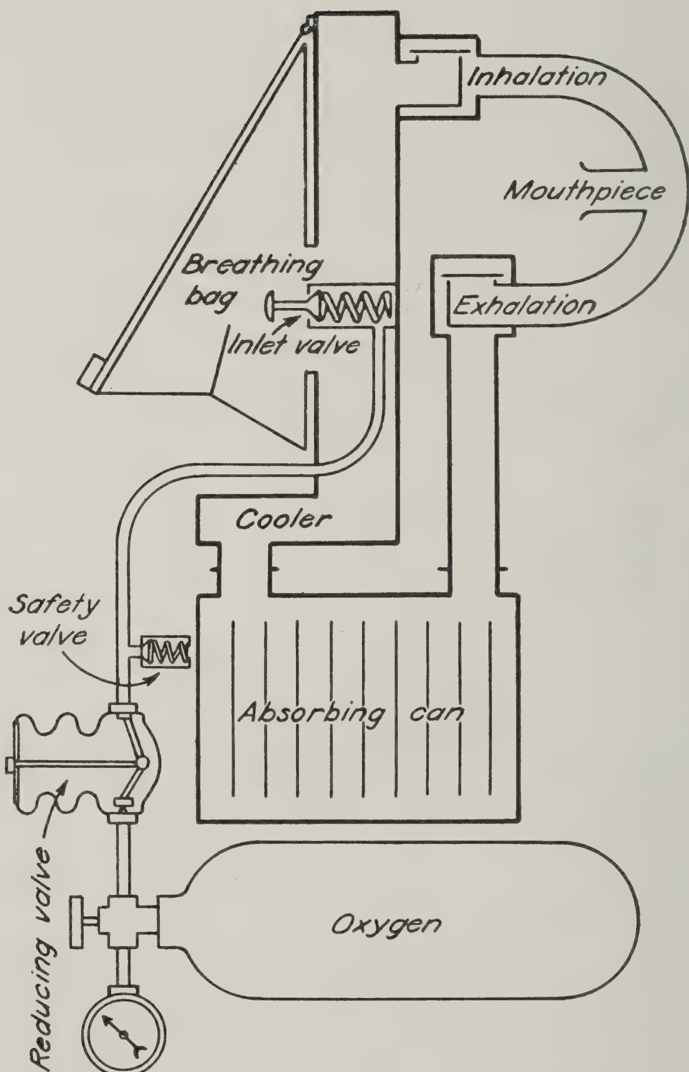
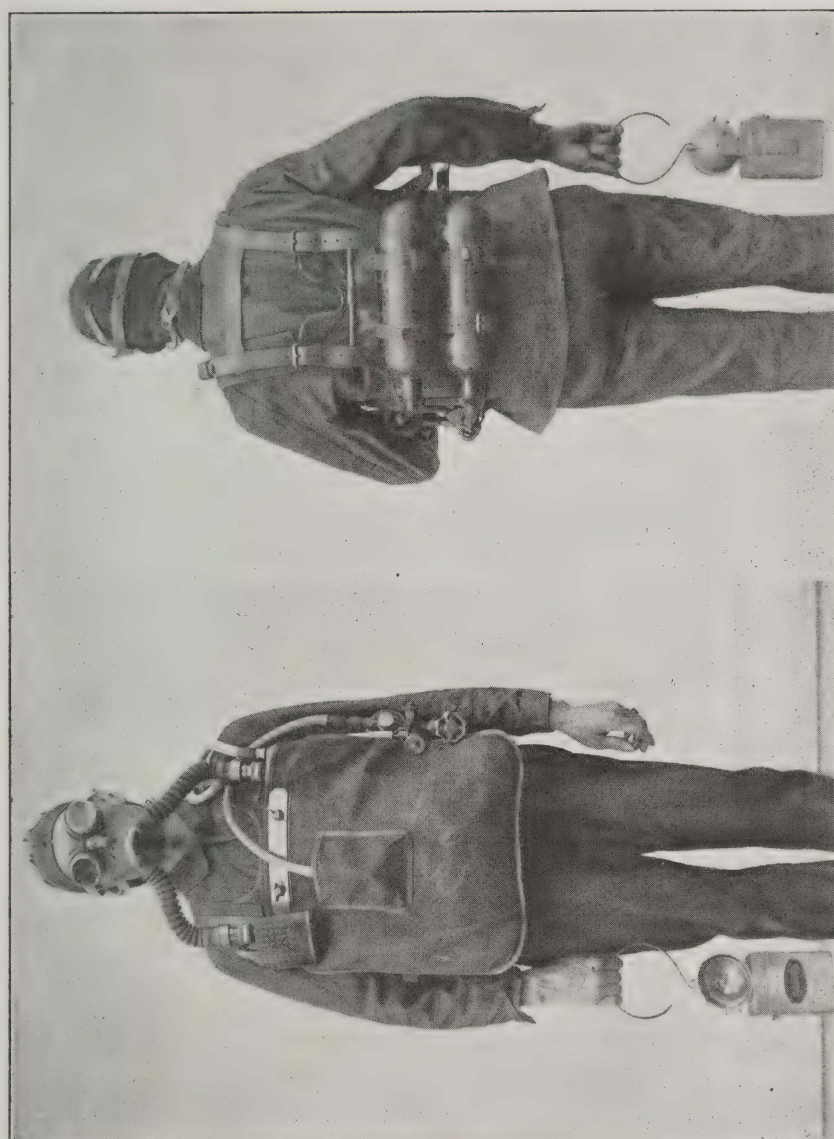


Fig. *B*. Circulating System of Gibbs Breathing Apparatus.



A. Fleuss or Proto Two-Hour Breathing Apparatus. *B.* Fleuss Two-Hour Apparatus, Back View.

hydrate. The avidity of the alkali for moisture is thus already partly satisfied, so that the amount of heat produced is considerably less than in other forms of apparatus, and the alkali is efficient at a much lower temperature.

Recently trial has also been made of an absorber somewhat closer to the Draeger or Westfalia type, but simpler in construction Anhydrous sodium hydroxide in granules is used, but in largely increased amounts. The efficiency and endurance of the absorber are thus increased, and owing to the greater bulk of the alkali the heat is so distributed that the tendency to the development of an excessive temperature is considerably reduced.

Methods of Ventilation.

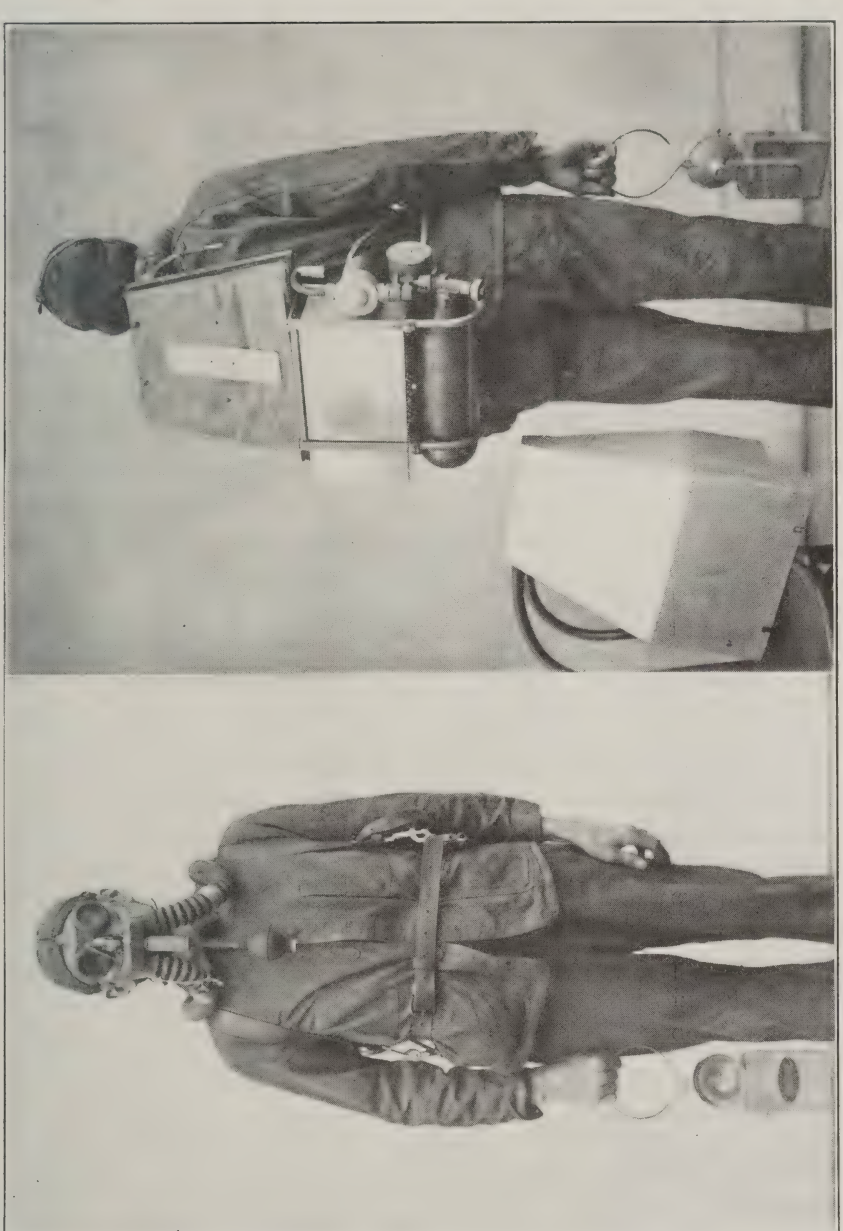
1. After an explosion a gallery must on no account be worked in until it has been ventilated by bratticing, or some other method, such as continuous air pumps.

2. Bratticing is the surest method and consists of dividing a shaft or gallery into two distinct passages by means of temporary partitions so as to form two air channels; one for the exit of the foul air and the other for the intake of fresh air. Waterproof sheets, blankets, canvas, and even piled up sandbags can be used for the purpose. The men working will require breathing apparatus.

3. Work should be commenced by bratticing the shaft and placing a brazier at the bottom of the foul air passage so as to cause an up-draught. Care must be taken that the bratticing comes 2 or 3 feet above the top of the shaft and is carried well down to the bottom, and that there is a free exit for the fumes so that they cannot creep down the shaft again.

4. Exploration of a mine after an explosion should always be progressive. After work on the shaft has been completed, bratticing should proceed along the gallery step by step. For men to go down rashly without precaution and get gassed only delays the resumption of work and may involve rescue parties in the disaster. Communication with the advanced party must be maintained by sight and a pre-arranged system of signals at fixed intervals. It is advisable that the advanced party should be roped to the parties in the rear to facilitate withdrawal in case of accident.

5. A small alarm gong should be provided with a string running along the roof of the gallery, which the workers can pull. It must be used only as a signal of distress.



A. Gibbs Two-Hour Apparatus, Front View. *B.* Gibbs Two-Hour Apparatus, Back View (Cover Removed).

The following data has been compiled from a British pamphlet "Memorandum on Gas Poisoning in Mines":

"HOW GAS POISONING IN MINES IS PRODUCED.

"By far the greatest number of these cases are the result of poisoning by Carbon Monoxide (CO). Even when present in very small proportion (0.1 per cent) this gas may, owing to its cumulative action, cause serious symptoms. The breathing of an atmosphere containing 0.2 per cent will cause loss of consciousness in 20 to 30 minutes in a man who is working, and, in course of time, death, which is painless.

"As Carbon Monoxide is not naturally present in the soil it can only result from the use of the explosives employed in firing enemy or our own mines. All explosives (both high and low) give off noxious fumes, the most important of which are CO and nitrous fumes.

"POISONING BY CARBON MONOXIDE.

"Under certain conditions large quantities of CO may be produced from all explosives. The amount will depend upon:

"(*a*) The type of explosive used. Guncotton, for example, produces more CO than any other high explosive: over 40 per cent if there is complete detonation and 54 per cent if detonation has been incomplete, when the charge is said to burn. After using this explosive it is often very difficult to clear a mine of the gas, as the disturbed ground and that in the vicinity appears to get quite saturated with it, and there is frequently trouble when the tamping is being removed. Ammonal, which is largely used in mining, is most hygroscopic, and in the presence of the least moisture may produce considerable quantities of CO.

"(*b*) *Quality.* Deterioration of the charge or detonators from whatever cause may lead to incomplete detonation of part of the charge, with the consequent production of large quantities of CO. Bad quality of explosive and of the detonators or insufficient, weak or damp detonators may cause this. These conditions may be produced when a charge has been laid and tamped for some time in damp workings.

"(*c*) The fact that explosives are used on such an enormous scale.

"Lachrymatory gas is sometimes used when galleries have been broken into to render the workings untenable. This does not often happen, but sponge goggles should be kept on hand in the Mine Rescue Stations for use in this emergency.

"THE ACTION OF CARBON MONOXIDE (CO).

"CO combines with the haemoglobin of the blood, displacing the Oxygen, so that all the tissues of the body suffer from Oxygen starvation. In addition, CO has a specific action on the blood, and through the blood on the nervous system. The serious after-effects are the result of the action of the gas on nerve matter rather than the deprivation for some time of a considerable percentage of Oxygen.

"The following points regarding CO poisoning should be kept in mind: Its action is intensified in the presence of other gases such as CO_2, and where there is diminished supply of Oxygen—in other words, where ventilation is defective. Increased muscular exertion, anxiety, excitement, marked mental strain, all hasten the action of CO, with the result that unconsciousness quickly supervenes. Men suffering from bronchitis, asthma or heart disease should not be employed in mines where there is any suspicion of CO—they are very susceptible to the action of this gas. Besides, a man who is constantly coughing in a gallery is a source of danger, silence being essential in all mining operations.

"Individual susceptibility plays a very important rôle in CO poisoning, some men being much more susceptible than others. Although a certain degree of tolerance to CO may become established, no man is immune against it. Men who have any inherent weakness of the nervous system are more susceptible to CO, and are likely, if exposed to considerable quantities, to develop certain nervous disorders. This explains some of the cases in which neuritis, etc., have developed after very short exposure to CO.

"AFTER EFFECTS OF CARBON MONOXIDE (CO) POISONING.

"Headache of a peculiar throbbing character is complained of by nearly all who have been gassed. Pain in the pit of the stomach, and vomiting and fluttering and palpitation of the heart, with breathlessness on the least exertion, are also complained of. Trembling is frequently seen. The patient generally complains bitterly of cold. Convulsions may be met with. On recovering conscious-

ness men are frequently dazed, confused, and stupid-looking. Other men become delirious, struggle and fight, talking in an incoherent manner, shouting, laughing, or crying. Care should be taken that these men do themselves no harm when they are being removed on the stretcher. Others again become very drowsy, great difficulty being experienced in rousing them.

"PREVENTION OF GAS POISONING AND ACCIDENTS IN MINES. (GENERAL INSTRUCTIONS.)

"*1. After a Mine Explosion.*

"1. When a 'blow' occurs, even though this appears to be a long way off, all men working below must come up at once.

"2. The officer in charge must be notified at once, and information sent to the nearest dugout where apparatus is stored, and to the Central Rescue Station, for the trained rescue men and apparatus. Where possible all the rescue apparatus and material should be carried by fatigue men in order that the rescue men may arrive at the mine perfectly fresh.

"3. Whenever a blow occurs all the trained mine rescue men are to proceed to the Central Rescue Station.

"4. The officer in charge is to superintend rescue operations and is responsible that all orders are obeyed. He should see that everything is done to improve the ventilation.

"5. No man is to descend the shaft without rescue apparatus till the mine is reported clear of gas.

"6. A sentry must be posted at once at the shaft head to carry out that order.

"7. Men who have had no previous training in the use of rescue apparatus are forbidden to use it.

"8. Infantry are prohibited from taking part in rescue operations. Where this order has been disobeyed, the would-be rescuers have been seriously affected and absorbed the attention of the trained rescue party to the prejudice of the men in the mine, and valuable time and lives thus lost.

"9. Rescue men should always work in pairs, never singly, unless under very exceptional circumstances.

"10. No naked lights are to be used in the mine till it is clear of gas. Electric lights only are to be used, as the gas in the mine may be present in explosive amount. When men are in a mine

when a blow occurs and their lights are extinguished, they should make their way out without relighting these; and where the force of the blow has not been sufficient to put out the candles, they must be immediately extinguished. A sufficient supply of C. E. A. G. lamps should be brought to the mine from the Rescue Station, as work is more rapidly carried out in a well-lighted shaft and gallery.

"11. The life line (which is to be used for no other purpose than rescue work) at the shaft head should be unwound ready for immediate use, and spare lines brought from the Rescue Station and kept in readiness.

"12. A strong canvas belt with a hook should be kept with the life ropes at the shaft head for use where mine stretchers are unavailable or cannot be used.

"13. Mine stretchers should be sent down the mine. No man who has been gassed is to ascend the shaft without being roped. Serious cases are to be brought up on the mine stretcher.

"14. Great care must be taken with all men, however slightly gassed, when they reach the shaft head, as exposure to cold often leads to loss of consciousness.

"15. Spare sets of Gibbs, Proto, Salvus and Novita should be brought to the mine. Spare cylinders of Oxygen and Caustic Soda should also be carried down—this will permit of each apparatus being used again.

"16. Before any apparatus is worn it must be carefully examined by the man who is actually going to wear it, special attention being paid to the valves and gauge. Cases have frequently occurred where men have had to leave rescue work owing to some small defect in the apparatus, which should have been adjusted before descending the mine. A spanner and spare noseclips should always be carried in the pockets. When a number of men are involved in a blow, a relief squad with apparatus ready should be in readiness to assist at a moment's notice. Whenever any defect is discovered, punctured bag, leaking valve, diminished supply of oxygen, overheating of caustic cartridge owing to exhaustion of caustic soda, etc., the wearer should immediately come out of the mine.

"17. Blankets, trench stretchers, hot water bottles and *café au lait* must be brought from the Mine Rescue Station and kept in readiness.

"18. Oxygen reviving apparatus (Novita) is to be taken into the mine by the rescue men whenever possible. Where there are a number of men poisoned and it is difficult to move them until further assistance arrives, oxygen may be administered; and in desperate cases it should always be given, as it will drive sufficient CO from the blood to permit the removal of the men with safety.

"19. Men should be warned that the gas helmet and box respirator issued to the armies for protection against hostile gas (chlorine, etc.) afford no protection against mine gas, as CO is not acted on by the chemicals in the helmet or box.

"20. Men who have been unconscious should, if possible, be kept in a dugout near the shaft head for at least two hours before being taken to the Dressing Station. Mild cases can be sent back to billets.

"2. *Precautions To Be Taken Where Gas Is Known To Be Present in the Galleries In Such Small Quantity That Work Can Be Carried Out, and Minor Symptoms of Gas Poisoning—e. g., Headache, etc., Only Develop After Prolonged Exposure.*

"1. Canaries or mice must be kept constantly in the mine, and changed every two hours.

"2. Should the canary or mouse show any signs of being affected, all the men must come up at once.

"3. When it is urgently required to carry out work in a gallery where exposure causes headache, etc., to develop in two hours, work should be carried out in relays, the men working 10 to 15 minutes with 30 minutes out.

"4. One Proto, one Salvus and one Novita, ready for instant use, should be kept at a place convenient to the shaft head; and two rescue men engaged in such surface work as will permit of them being in instant readiness should their services be required.

"TREATMENT.

"Proceed to treat the patient instantly. The points to be aimed at are: First, and immediately, the restoration of breathing, and secondly, after breathing is restored, the promotion of warmth and the circulation. The efforts to restore life must be perservered in until the heart and breathing have ceased for an hour.

"1. To Restore Breathing.

"Artificial Respiration and Administration of Oxygen.

"The administration of oxygen is of the utmost value in gas poisoning in mines. It drives out the CO from the blood five times more quickly than air. Oxygen is administered by means of the Novita oxygen reviving apparatus, which is kept at Mine Rescue Station and Advanced Dressing Stations. In using this the mask should be properly applied over the face, and the valve so adjusted as to keep the india-rubber bag about half full of oxygen. The method of administering oxygen through a nozzle held to the mouth or nose is almost valueless in gas poisoning, as most of the oxygen escapes into the atmosphere.

"In all cases where breathing has stopped or become shallow. the giving of oxygen should be combined with artificial respiration until the breathing becomes sufficiently deep to enable the blood to be cleared of CO and replaced by oxygen. Schaefer's method is the one adopted in mine rescue work. In serious cases the administration of oxygen should be persisted in for about half an hour, by this time the oxygen-carrying power of the blood should be sufficiently restored to ensure recovery.

"Treatment After Natural Breathing Has Been Restored.

"Stop artificial respiration but still continue for some time giving oxygen by the Novita. This will have the effect of lessening the severity of the after effects, which, in some cases, are very distressing.

"2. To Induce Circulation and Warmth.

"(a) Warmth.

"Owing to the action of CO in reducing temperature, warmth in the treatment of all gas poisoning cases is essential. Whenever gas poisoning cases occur, blankets and hot water bottles should be brought from the Mine Rescue Station. It is frequently found that those who have been seriously gassed collapse when exposed to the cold air, and many who have apparently recovered when below suddenly become unconscious when they reach the shaft head. Wrap the patient in dry blankets and promote warmth of body by hot water bottles, heated bricks, etc., applied to the pit of the stomach, the armpits and sides of chest, and the soles of the feet. Energetic friction of the skin of the chest, and of the limbs in an upward direction, will not only increase body heat but stimulate the circulation.

"(*b*) *Rest.*

"This is absolutely essential in treatment. The importance of this in milder cases is apt to be overlooked. Under no circumstances must the patient be walked about after he has come to. This is frequently done in those cases where the patient gets into a drowsy state. Muscular exertion means the needless expenditure of the small available supply of oxygen in the blood, and attempts at walking may lead to loss of consciousness. If possible, no man who has been gassed should be permitted to march back from the trenches. Men who have been unconscious should, if possible, be kept in a dugout near the shaft head for at least two hours, before being taken to the dressing station. It will be found, if rest is insisted on, that recovery will be greatly accelerated and serious after-effects will be avoided.

"(*c*) *Stimulants.*

"In mild cases hot strong coffee should be given. No other stimulant is to be given. In serious cases a hypodermic injection of strychnine will be found of great value. Where this appears necessary no time should be lost in sending for the Medical Officer.

"(*d*) *Emetics.*

"It is still common to find that salt and water has been given as an emetic as soon as the patient recovers consciousness. Certain men complain of pain in the stomach, which is generally relieved by vomiting. There is no objection to giving an emetic to mild cases, but where a man has been unconscious and seriously gassed it should never be given, on account of one grave danger, viz: the possibility of the patient relapsing into a comatose condition, so that insufflation pneumonia may result.

"*Warning.*

"In all serious cases of gas poisoning the patient must be carefully watched, as relapses are frequent. If the breathing again becomes shallow or threatens to cease, artificial respiration, with administration of oxygen, should immediately be resorted to.

"Phenacetin, aspirin, and such drugs should never be given to relieve the intolerable headache, which is one of the most distressing after-effects of gas poisoning; serious attacks of heart failure have followed the administration of such drugs."

Mine Rescue Organizations and the establishment of Mine Rescue Stations will be taken up in later notes.

Book Reviews.

Deductions from the World War. By Baron von Freytag-Loringhoven, Lieutenant General and Deputy Chief of the German Imperial Staff. New York and London, G. P. Putnam's Sons, 1918. xi. 212 pp. 19 cm.

An introductory note says: Baron von Freytag-Loringhoven, the author of this book, is the most distinguished soldier-writer of Prussia. That, in other words, since none will dispute Prussia her militarism, he is the most distinguished living writer on militarism in theory and practice. It further says:

"Deductions from the World War," was written for German consumption. As soon as a few German newspaper reviews called attention to its contents, and especially to the chapters, "The Army in the Future," and "Still Ready for War," with their candid explanation of the way in which Germany proposes, this war finished, to prepare for the next, all comment was restricted or suppressed. Circulation of the book in Germany was promoted, but its export was prohibited, and very few copies have found their way across the frontier.

This book is a revelation because he says what Germany thinks. "War has its basis in human nature," he writes. . . Militarism is not a Prussian invention; militarism is Prussia herself.

Freytag first treats of the Political and Economic Situation of the Central Powers giving an excellent analysis of the influence of geographic situation, agriculture, trade, economics in general, and land and sea power, upon the history of the last two centuries.

He then explains the wonderful influence, moral and physical, of universal military education and service in the development of nations during this period.

He then very clearly discusses the influence of Technical Science,

especially in very recent years, on communications, aeronautics and new weapons, and on their effect on strategy, grand tactics, fortification, etc.

> Speaking of leadership, he says: In view of the development of modern Technical Science, it was inevitable that the World War should exhibit many characteristics different from those of earlier wars. None the less, it would be a great error to declare all experience gained from previous wars to be out of date. . . The instruction gained from the past must be further developed and adapted to present day conditions.

He quotes extensively from Frederick, Napoleon, Clausewitz, Moltke, and others showing how the strategy and grand tactics of Hannibal, Frederick, and Napoleon were applied on a vastly greater scale.

He explains why under certain circumstances, even Napoleon and Frederick, frequently advocated intrenched positions. "Hence it would be wrong to maintain that, in the future, entrenched warfare must necessarily play such a dominant part as it has in the present war."

This chapter on The Army in the Future, while bristling with Prussianism, contains some good suggestions about the organization of armies both in a republic and in a despotism.

In conclusion he says that Germany must be "Still ready for War."

> . . . In any event as regards us Germans, the World War should disencumber us once and for all of any vague cosmopolitan sentimentality. . . . In the future, as in the past, the German people will have to seek firm cohesion in its glorious army and in its belaurelled young fleet.

The eyes of all the world are now turned to the problem of military organization, upon which the very existence of a state is founded. Germany would make the military independent of and superior to the civil power. Freytag supports his side with arguments that are mainly interesting to the student of German psychology.

If due allowance is made for his obsession, the book will have great value in presenting the views of an accomplished soldier on the great problems of the warfare of to-day.

Tactics and Technique of River Crossings. By Mertens, Colonel and Chief of Section in the Engineer Committee, German Army; Translated by Walter Krueger, Major and Assistant Chief of Staff 84th Division, National Army, with 105 illustrations and four maps. New York, D. Van Nostrand Co. ix, 253 pp., 105 illustrations; 4 maps. 23 cm.

In the preface the author states his purpose in writing the book, "to do my share in raising the appreciation in our army of the importance of co-operation between the pioneers and the other arms to the end that the technical duties of my corps and its special training in combats for the possession of river crossings may be fully utilized in obtaining tactical success." Major Krueger will be remembered as the translator of volumes 1 and 2 of Balck's "Tactics." He states in his preface that the worth of the subject matter and its great importance in the present world war has prompted him to give this tactical work to our army.

"Tactics and Technique of River Crossings," exhibits the thoroughness characteristic of German military publications. It is well illustrated with 105 diagrams and presents many examples of river crossings taken from the military history. The great influence of river crossings on military operations in the past is clearly pointed out, from which many lessons are drawn. Strong emphasis is placed on the absolute necessity of studying the tactics of river crossings and not alone the technique for a river crossing, no matter how technically perfect, is of but little value to an army if the tactical situation is poor and may even prove to be a source of great disaster. Various methods of attacking and defending a river line are thoroughly discussed and the tactical features of importance are clearly pointed out. The book is, in fact, a tactical study of river lines and river crossings rather than a technical treatise. Different methods of crossing rivers by means of small rafts, improvised from barrels, boards, fascines, etc., which are the results of experiments by the German Pioneer Corps, are pointed out. The use of shelter tent bundles as floats in forming small rafts and for supporting light foot bridges is emphasized. A good many of the methods which are given for crossing streams seem to be suitable only for the small streams prevalent in Europe, and would hardly be applicable to the large swift rivers found in this country.

It seems to be the German conception that ponton boats are to be used primarily for ferrying troops across streams rather than as supports for a floating bridge, the idea being that ferrying should start immediately and while this is in progress, material for an improvised bridge is to be gathered and put into place. This, too, would hardly be applicable to a stream of any considerable size and velocity.

The book contains two good tactical studies of river crossings over the Rhine and the lower Oder, accompanied by four maps. These studies are based upon General von Falkenhausen's study of the operations of the gigantic armies of the future, as set forth in his "*Flankenbewegung und Massenheer,*" published in 1911.

This book of 253 pages is very "readable" and is well worth studying by the officers of our army, especially by the officers of the Corps of Engineers.—J. H. Anderson, Captain, National Army.

AERIAL PHOTOGRAPHY.*

C. SOCIETY PAPERS, MONOGRAPHS, TRANSACTIONS, ETC., INCLUDING PUBLICATIONS OF LEARNED INSTITUTIONS.

93 ABBADIE, A. d'

Rapport sur la planchette photographique de M. Auguste Chevallier. Commissaires: M. M. Cortambert, Jacobs, Lourmand, Malte-Brun, d'Abbadie, rapporteur. (Soc. Géog. 5e série, t. iv. Juillet-déc. 1862, p. 373-386.) LC. (G11S4, 5. s. v. 4.) See also: Paté, Edouard.

94 BAGLEY, JAMES WARREN.

The use of the panoramic camera in topographic surveying, with notes on the application of photogrammetry to aerial surveys, by James W. Bagley. Wash., Govt. print. off., 1917.

88 p. xv pl. (part fold., incl. maps,) fold. tab., diagrs. 23½ cm (U. S. Geo. S. Bull. 657.)

At head of title: Department of the interior.

Maps are in pocket. LC. (TA593 B3 and QE75 B9 no. 67.) ES. UG.

Aerial photography, p. 20. Stereophotogrammetry, p. 19. Application of photogrammetry to aerial surveys, p. 64. District reconnaissances from airplanes, p. 69. Rapid route reconnaissance from airplanes, p. 84. Jardinet tube, p. 67, 68, 82. Form of triangular base for determining positions of aerial photographic stations, fig. 8, p. 67.

95 BELLAK, PAUL.

Scheimpflug's aerophoto-grammetrie und der krieg. Aer. Club, ix. Jhrg., no. 1. Jan., 1915, p. 14-16. Sm.

Reviews the work done by Scheimpflug and Kammerer, and gives a brief description of a camera for military scouting.

96 BOUCHER.

Le ''Monobloc,'' appareil stéréo-panoramique, muni d'un dispositif special facilitant la photographie en couleurs. (Séance générale du 20 janvier 1911.) Soc. F. Phot. Bulletin. 57e année. 3e série t. ii., janvier, 1911, p. 108-111, incl. 2 illus. LC. (TR1. S6. 3. ser. v. 2, 1911)

97 BRUECKNER, EDUARD.

Oberleutnant E. von Orels stereoautograph als mittel zur automatischen herstellung von schichtenplänen and karten. Besprochen von prof dr. Ed. Brückner. k. k. Geog. G. Band 54, heft 4 ,1911, p. [227]-242. 5 outline figs. and Illus. 4 plates. LC. (G9G3, v. 54.)

Fig. 4, C. Pulfrichs stereomikrometer. Fig. 5, C. Pulfrichs stereokomparator. Plate 1 Die insel Pomo im adriatischen meere. S. M. S. "Najada" vor Pomo. Plate 2. Oberleutnant E. von Orels stereoautograph. Plate 3. Aufnahme des gehänges des Hinteren Seelenkogels . . . im Pfeldererertal.

Plate 4. Schichtenplan . . . im Pfeldererertal.

98 DEVILLE, ÉDOUARD GASTON DANIEL.

Lever topographique des montagnes rocheuses exécuté par la photographie. Par M. E. Deville . . . (Soc. F. Phot. 2e serie, t. ix, no. 15, 1893, p. 357-361.) LC. (TR1S6, 2. ser. v. 9.)

99 DOLEZAL, EDUARD.

Das rückwärtseinschneiden auf der sphäre, gelöst auf photogrammetrischem wege. 1. Abhandlung. Mit 1 textfigur. Vorgelegt in der sitzung

*Aerial Photography. Bibliography, etc., continued from May-June, 1918, page 436.

am 7. juli 1910. Kais. Akad. W. W. v. cxix. band, heft vii. Juli, 1910, p. 1223-1256. Sm.

i. Photogrammetrische winkelmessung, p. 1228. ii. Genauigkeit der photogrammetrischen winkelmessung. iii. Photogrammetrische positionsbestimmung.

100 FINSTERWALDER, SEBASTIAN.

Eine grundaufgabe der photogrammetrie und ihre anwendung auf ballonaufnahmen. K. Akad. W. M. Band 22. 2. abteilung, 1903-4 [Denkschriften, bd. 75] München, 1906, p. 223-260. 2 plates.
LC. (AS182 M822)

101 FOURCADE, H. G.

On a stereoscopic method of photographic surveying. South A. P. S. v. xiv, part 1, April, 1903.

102 GIRARD, AIME.

Analyse des travaux de M. Laussedat sur l'application de la photographie au levé des plans. From Journal des débats. Soc. F. Phot. t. xi, mars, 1865, p. 69-75. L. C. (TR1 S6.)

103 HOUDAILLE.

Sur le calcul et la construction du télé-objectif panorthoscopique de Clément et Gilmer. Par M. le capitaine Houdaille. Soc. F. Phot. 2e série, t. ix, no. 15, 1893, p. [353]-356. LC. (TR1 S6, 2. ser. v. 9.)

104 JAVARY.

Mémoire sur les applications de la photographie aux arts militaires. Par Javary, capitaine du génie. Mém. O. G. 2e série, t. vii, no. 22, 1874, p. 365-427, incl. illus. diagrs. Plate 11. ES.

Application de la photographie aux levers, p. 365.—Des appareils à panoramas, p. 403.—Reproductions photographiques, p. 413.

105 KAMMERER, G.

Der topograph im ballon. Aer. Club. vii. jhrg., no. 12, Dec., 1913, p. 272-277. 6 half-tones. Sm.

Text in German and French.

Fig. 1. Photo-perspektograph.—Fig. 2. Universal photo-perspektograph, Scheimpflug-Kammerer.—Fig. 3. Panorama-apparat vor dem ballon-korb montiert.—Fig. 4. Original-aufnahme mit panorama-apparat.—Fig. 5. Transformiertes panorama.—Fig. 6. Luftkundschafter camera.

106 KLINGATSCH, ADOLF.

Ein zweihöhenproblem in der photogrammetrie, von prof. Adolf Klingatsch in Graz. (Vorgelegt in der sitzung am 18. Nov., 1909.) Kais. Akad. W., W. cxviii. band. Abtheilung iia. heft x. Dec., 1909, p. 1523-1543 incl. 1 diagr. tables. LC. (AS142. V311 v .118-2a.)

107 KLINGATSCH, ADOLF.

Zur photographischen ortsbestimmung, von dipl.-ing. Adolf Klingatsch, o. ö. prof. der k. k. technischen hochschule zu Graz. (Vorgelegt in der sitzung am 4. März 1909.) Kais. Akad. W. W. cxviii. band. Abtheilung iia. heft 4 April, 1909, p. 485-509, incl. 1 diagr.
LC. (AS142. V311, v. 118-2a.)

108 LAUSSEDAT, AIME.

Mémoire sur l'application de la photographie au lever des plans. Mém. O. G. 2e série, t. ii, no. 17, 1864, p. 251-314, incl. diagrs. ES.

109 LAUSSEDAT, AIME.

Mémoire sur l'emploi de la chambre claire dans les reconnaissances

topographiques. Mem. O. G. 2e série, t. i, no. 16, 1854, p. 206-247. Planches xiii et xiv. ES.

110 LAUSSEDAT, AIMEE.

Note sur la construction d'une minute à l'échelle de 1:20,000, de la carte d'une partie des montagnes rocheuses du Canada, à l'aide de vues photographiques. Par M. A. Laussedat. Soc. F. Phot. 2e série, t. ix, no. 14, 1893, p. 339-341. LC. (TR1S6, 2. ser. v. 9.)

111 LOUIS, HENRY.

A new device for tacheometric plane-table surveying. Inst. Civ. E. v. cciii, 1917. Paper no. 4226. p. [359]-361. LC. (TA1 I6, v. 203.) ES.

Treats on the "Patent compensating subtense diaphragm," made by W. F. Stanley & Co., lim., with brief mention of the instruments by Ljungström, and Prof. Jeffcott, the latter made by Thomas Cooke & Sons, lim.

112 LUMIERE, AUGUSTE ET LOUIS.

Nouvel appareil photographique panoramique réversible "Le Photorama." Soc. F. Phot. 2e série, t. 18, no. 5, 1902, p. [121]-132, incl. illus. diagrs. LC. (TR1 S6, 2. ser. t. 18.)

113 MINA, LUIGI.

Della determinazione del punto in pallone mediante la declinazione magnetica approssimata. Soc. Aer. Ital. Genaio, 1909.

114 MOESSARD, P.

Les panoramas photographiques et les appareils panoramiques. Soc F. Phot. 2e série, t. ix, 1893. LC. (TR1 S6. 2. ser. v. 9.)

115 MOESSARD, P.

Projections panoramique. Par M. le commandant Moëssard. Soc. F. Phot. 2e série, t. viii, no. 8, 1892, p. 216-217.

LC. (TR1 S6, 2. ser. v. 8.)

116 MOESSARD, P.

Le "Tourniquet"; par M. le Commandant Moëssard. Soc. F. Phot. 2e série, t. ix, no. 12, 1893, p. 296-301. LC. (TR1 S6. 2. ser. v. 9.)

118 PIVER, L.

Mode de suspension de chambres noires sur les navires ou dans les ballons. Soc. F. Phot. 2e série, t. vii, no. 11, 1891, p. 405-407, incl. 1 illus. LC. (TR1 S6, 2. ser. v. 7.)

Illustration: "Suspension d'un appareil 18x24 à double chambre construit par M. Martinet.

119 SCHEIMPFLUG, THEODOR.

Die herstellung von karten und plänen auf photographischem wege. Von Theod. Scheimpflug, k. u. k. Hauptmann d. R. und Kapitän l. F. Mit 6 textfiguren. Vorgelegt in der sitzung am 7 März, 1907. Kais. Akad. W. W. cxvi. band. abtheilung iia. Jahrgang 1907, heft 2. p. 235-266, incl. illus. diagrs. LC. (AS142. V311, v. 116, 2A, 1907.)

Contents.—Ueberblick über die leitenden gesichtspunkte der methode.—ii. Die geodätische orientierung der ballonbilder und ihre transformation in horizontierte vogelperspektiven mit hilfe des photoperspektographen.—iii. Die ermittlung des genauen schichtenplans des terrains aus den horizontierten und geodätisch orientierten ballonaufnahmen. A. Ermittlung des schichtenplanes ohne besondere instrumentelle hilfsmittel. B. Ermittlung des schichtenplanes mit hilfe des stereokomparators.—iv. Die zonenweise überführung der horizontalen vogelperspektiven in orthogonalprojektionen. v. Die herstellung der karte auf photographischem wege.

120 SELBSTTAETIGE FLUGZEUG-TERRAIN AUFNAHMEN.
Aer. Club. ix. jhrg., no. 1. Jan., 1915, p. 92-94. "(Auszug.)" Sm.
Signed D.

An extract of an article by H. Bannermann-Phillips in the Scientific American, relating to the Fabbri automatic camera. This camera is an invention of Capt. Giovanni Fabbri of the Italian Aerial Corps.

121 THIELE, R.
Note sur l'histoire des expériences et des applications de la métrophotographie en Russie et descriptions de l'autopanoramographe de M. Thiele. (Communication faite à la section "Laussedat.") Soc. F. Phot. 57e année. 3e série t. ii. Sept., 1911, p. 301-328, incl. diagrs.
LC. (TR1 S6, 3. ser. v. 2.)

122 TSCHAMLER, IGNAZ.
Studie zu dr. Pietschmanns photogrammetrischen aufnahmen in Mesopotamien im jahre 1910. Von Ignaz Tschamler, tech. oberoffizial im k. und k. Militär-geographischen institut zu Wien. K. K. Geog. G. W. v. 54, heft 8, 1911, p. [409]-431. 11 plates, 1 map. LC. (G9G3, v. 54.)

Kritische betrachtung des verwendeten apparates und der angewendeten methode, p. 423.—Ballonphotogrammetrie, p. 424.—Anwendung des panoramenapparates mit schiefen bildern, p. 426.—Die stereophotogrammetrische höhenvermessung dieser aufnahmen, p. 427.—Ballonphotogrammetrische aufnahmen während flüchtiger reisen, p. 429.—Mesopotamien, das land der ersten ballonphotogrammetrischen vermessung, p. 430-431.

123 WRIGHT, CHARLES WILL.
The panoramic camera applied to photo-topographic work. Am. I. M. E. no. 19, Jan., 1908, p. [101]-116, incl. illus.
ES. LC (TN1 A5 1908.)

D. ARTICLES FROM PROFESSIONAL AND OTHER PUBLICATIONS.

124 [ALL-RUSSIAN AERONAUTIC CONGRESS, 1ST, ST. PETERSBURG, 1911.]
Erster allrussischer luftschifferkongress in St. Petersburg im früjahre 1911. [Short report on the labors of the congress.] Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 293-294. 240 words.

The following questions were proposed by State councillor and engineer R. Thiele, and adopted after discussion, viz:

1. Concerning the application of photogrammetry in aeronautics. 2. Concerning aviation maps.

Photographs will be taken by engineer Thiele by means of his "Panoramographs" attached to a kite balloon. He showed what enormous chances would offer themselves for the speedy and accurate measurement of obsolete maps through aerophotogrammetry. He had accomplished the restitution of the topographical aeronautic map for the St. Petersburg aerial contest, and produced a part of this map, the route Moscou to Klien before the congress. This sheet has a square measure of 90 by 45 verst, scale 1:168000.

125 APPAREIL TELEPHOTOGRAPHIQUE DE FORTERESSE.
Rev. du G. M. 21e année, t. xxxiv, 2e semestre. Août, 1907, p. 155-156, incl. outline fig. ES. LC. (UG1 R4 v. 34.)

Heading: Science, physiques. etc.
An abstract from the "Bulletin de la Société française de photographie," 15 jan., 1907.

126 Appareil Telephotographique Destine a la Photographie en ballon. Rev. du G. M. 21e année, t. xxxiii. 1er semestre, mars, 1907, p. 259-261. ES. LC. (UG1 R4 v33.)

Heading: Science, Physiques, etc.

Abstract of an article by Lieut.-Col. Houdaille, in "Bulletin de la Société française de photographie," 1 nov., 1906. The apparatus was made by Fleury-Hermagis. who was awarded the gold medal for it at the competitive exhibition of 1900.

127 Astronomische Ortsbestimmung im Ballon.
Int. Arch. P. Band ii, heft 3 Juni, 1911, p. 226.

Short note giving "Literature" on the subject.

128 Bache, Richard Meade.
Balloon photogrammetry. Prof. R. Meade Bache, U. S. Coast and Geodetic Survey. Mil. Service I. v. xv, no. 68, March, 1894, p. 372-376.
AW. ES. LC. (U1 M6 v15.)

Read before the American Philosophical Society.

[Reprinted] from the American Journal of Photography. By permission.

129 Bassus, Konrad, Freiherr von.
Ballonphotogrammetrie. Von K. Bassus, München. Illus. aer. M. 4. Jhrg., no. 4, Oct., 1900, p. [33]-38, incl. diagrs. WB.

130 Bassus, Konrad, Freiherr von.
Photogrammetrischer apparat für die luftschiffahrt bei welchem die photographische camera in einem bestimmten neigungswinkel an einen schulter-anschlag mit libelle sitzt. Illus. aer. M. 4. Jhrg., no. 4, Oct., 1900, p. [83]. 1 diagr. WB.

Treats on a pistol-camera.

131 Bassus, Konrad, Freiherr von.
The same. ibid., xii. Jhrg., no. 2. April, 1908, p. 79-80. 5 figs. 2 tables. Sm.

132 Bassus, Konrad, Freiherr von.
Prüfung von photographischen moment-verschlüssen. Illus. aer. M. xii. Jhrg., no. 2. April, 1908, p. 76-80. 5 figs., 2 tables. Sm.

133 Bennati, L.
La fotografia nelle sue applicazioni militari. L. Bennati, capitano d'artiglieria. Riv. Art. G. Anno 1892, v. ii, p. [55]-82.
AW. LC. (U4R6 v2, 1892.)

i. La fotografia applicata alla cartografia, p. 57-60.—ii. La fotografia i piccioni viaggiatori, p. 60-64.—iii. Fotografia in pallone, p. 64-69.—iv. La fototopografia, p. 69-75.—v. La fotografia nelle ricognizioni topografico-militari, p. 75-82.

134 Berget, Alphonse.
Les applications de l'aéronautique à la géographie. Rev. Geog. A. Année 1909, t. 3, p. [551]-571, incl. diagrs. 4 plates.
LC. (G1R43, 1909, v. 3.)

135 Berget, Alphonse.
Les méthodes et les instruments du géographie voyageur. Rev. Geog. A. Année 1908, t. 2, p. [511]-559, [560], incl. illus. diagrs.

At head of title: Topographie.

"Bibliographie": p. [560]. LC. (G1R43, 1908, v. 2.)

Illustrations.—1. Théodolite topographique à réflexion. 2. Transformation de cet instrument en photothéodolite.

136 BOUTTIEAUX.

La téléphotographie. Bouttieaux, Capitaine du Génie. Rev. du G. M. 11e année, t. xiv, 2e semestre. Sept., 1897, p. [193]-235, incl. diagrs. illus. ES. LC. (UG1R4 v14.)

chap. 1er. Appareils à employer. 1. Appareils simples à long foyer.—2. Longues-vues photographiques et téléobjectifs.—chap. iie. Téléphotographie en ballon.—Appareils à employer en ballon captif, p. 224; . . . en ballon libre, p. 226.—Emploi de ballons non montés et de cerfs-volants, p. 227.—chap. iv. Applications de la téléphotographie, p. 233.

137 DIE BRUESSLER KONFERENZ DER INTERNATIONALEN KOMMISSION für die luftschifferkarte, Bruxelles, 26, 27 mai, 1911.

[Short notice relating to labors of the International commission for aeronautic maps, in conference at Brussels, 26th, 27th May, 1911.] Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 296. 400 words.

There were 22 delegates present from various states of Europe. The following points were decided upon by the conference: 1. Scale. 2. Demarcation of the map and deciding upon the limits of separate sheets. 3. Denotation of sheets. 4. Spelling of geographical names.

Professor baron Berget read a paper during the conference, in the Belgian Aero-Club, on:

La topographie et l'aéronautique," in which he supported the application of balloon photogrammetry enthusiastically for the purpose of creating an uniform aerial map.

Report on this conference, by Karl Peucker, in: Petermann's mittheilungen, v. 57-ii, July, 1911, p. 31-34. LC. (G1P3 v. 51-2.)

138 CAMPOS, CARLOS MARTINEZ DE.

Artilleria y aviación. Su empleo y su enlace en la guerra moderna. Por Carlos Martinez de Campos, capitán de artilleria [Spanish army]. Mem. Art. Año 72, serie vi, t. xii, entrega 5a; entrega 6a. Nov., dic., 1917, p. 525-572; 675-738. CA.

The author of this article describes on p. 715-719, a new aerial telephotographic apparatus of Capt. Jeveois.

An abstract of the contents of pages 715-719 was published in: Riv. Art. G. Dic., 1917, p. 234. 60 words. 1 plate of 3 figs. ES. L. C. (U4R6 1917.)

The original contains no illustrations showing the apparatus.

Illustrations. 1. Apparato con magazzino per 12 lastre. 2. Stazione di Winterthur. 3. Casérma a Wintherthur.

139 CHAUMONT, H.

Des axes optiques inclinés en téléphotographie. H. Chaumont, Lieut., d'artillerie. Rev. du G. M. 22e année. t. xxxv, 1er semestre. Janvier, 1908, p. [33]-52, incl. diagrs. ES. LC. (UG1 R4 v35.)

140 CROUZET, E.

Etude sur l'emploi des perspectives et de la photographie dans l'art des levers du terrain. Par E. Crouzet, Colonel du génie en retraite. Rev. du G. M. 15e année. t. xxii. 2e semestre. Dec., 1901, p. [529]-556; 16e année, t. xxiii, 1er semestre. Janvier, 1902, p. [63]-94, incl. illus. diagrs. LC. (UG1 R4.) ES.

Chambre claire du colonel Goulier, fig. 4, p. 540.—Télémétrographe. Téléiconographe, p. 541. Appareil Laussedat, p. 543. Travaux du capitaine Javary, p. 547. Perspective cylindriques—rayonnantes, p. 551. Planchette Chevalier, p. 522, and figs. 5, 6, p. 553-554. Périgraphe instanté Mangin, p. [63], and fig. 7, p. 64. Orographe Schrader, p. 66, and fig. 8, p. 67. Photographies en ballon, en cerf-volant, etc., p. 80-82. Travaux exécutés par la métrophotographie, p. 82-88. Lever du Mont-Blanc, par MM. Joseph et Henri Vallot, p. 88-94.

141 DEVILLE, EDOUARD GASTON DANIEL.

Colonel A. Laussedat. By E. Deville, Surveyor general in Canada. Int. Arch. P. Band ii, heft 3. Juni, 1911, p. 219-221.

142 DOKULIL, THEODOR.

Neue instrumente für die photogrammetrische aufnahme von baudenkmälern. Von Ingenieur dr. Theodor Dokulil. Adjunkt an der k. k. Technischen hochschule in Wien. Int. Arch. P. Band ii, heft 2. Oct., 1910, p. 79-103; heft 3. Juni, 1911, p. 153-188, incl. illus. diagrs. tables.

i. Grundprinzipien für die konstruktion eines universal-phototheodolites. ii. Einrichtung des universal-phototheodolites. iii. Die eigenschaften des phototheodolites und seine rektifikation. iv. Die bestimmung der bild-distanz des phototheodolites. v. Der gebrauch des universal-phototheodolites. vi. Die einrichtung des photokoordinameters. vii. Der gebrauch des photokoordinameters. viii. Genauigkeit einer mit den vorstehend beschriebenen instrumenten ausgeführten photogrammetrischen aufnahme und rekonstruktion.

143 DOLEZAL, EDUARD.

Ein beitrag zur stereophotogrammetrie. Von E. Dolezal . . . Int. Arch. P. Band 1, heft 2. Juli, 1908, p. 116-134, incl. diagrs.

144 DOLEZAL, EDUARD.

Hofrat professor dr. Anton Schell, weil. o. ö. professor der praktischen geometrie an der k. k. Technischen hochschule in Wien. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. [1]-8, incl. port. (front.), and autograph.

[His writings]: p. 7-8.

Schell was born at Baden, near Vienna, Nov. 17, 1835, + at Vienna, Feb. 9, 1909.

145 DOLEZAL, EDUARD.

Oberst Aimé Laussedat, der begründer der photogrammetrie, sein leben und seine wissenschaftlichen arbeiten. Von E. Dolezal, o. ö. prof. an der k. k. technischen hochschule in Wien. Int. Arch. P. Band 1, heft 1. März, 1908, p. [3]-15. Port. (front) and autograph.

[Born at Moulis April 19, 1819, + at Paris, March 18, 1907.]

"Zusammenstellung von publikationen Laussedats," p. 13-15.

146 DOLEZAL, EDUARD.

Theodor Scheimpflug, k. und k. Hauptmann und kapitän langer fahrt. Sein leben und seine abeiten. Von prof. E. Dolezal. Int. Arch P. Band ii, heft 4. Oct., 1911, p. [241]-249, incl. portr, (front).

Obituary.

[His writings]: p. 248-249.

147 [DOLEZAL, EDUARD.]

Ueber ballonphotogrammetrie. Int. Arch. P. Band 1, heft 4. Feb., 1909, p. 301-304.

Abstract of a paper read by Prof. Dolezal on Jan. 9, 1909, before the "Oesterreichische ingenieur-und architekten-verein," Wien. Signed: Dokulil.

148 DOLEZAL, EDUARD.

Ueber die photokatastral-methode von Gautier. Von prof. E. Dolezal in Wien. Int. Arch P. Band 1, heft 4. Feb., 1909, p. 278-294, incl. diagrs. figs., tables.

149 DOWLING, D. B.

The determination of heights in plotting from photographs. By D. B. Dowling and H. Matheson, Geological survey of Canada. Int. Arch P. Band 1, heft 2. Juli, 1908, p. 104-107, incl. diagrs.

150 Emden, R.

Ein infaches verfahren zur bestimmung des hautpunktes. Von. dr. R. Emden, a. o. professor an der Technischen hochschule in München. Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 285-286, incl. diagr.

151 [Fenner, P.]

Die photogrammetrie in Italien. Zeitsch. verm. Band xxi, heft 23. 1. Dec., 1892, p. 635-639

Signed: F., Aachen, Oct., 1892. CG.

152 Finsterwalder, Sebastian.

Ballonphotogrammetrie. Photog. R. xiii. Jhrg., p. 207-211. Sm.

At head: "Vereisnachrichten."

153 Finsterwalder, Sebastian.

Photogrammetrische aufnahme von höhenkarten vom ballon aus. Illus. aer. M. 4. Jhrg. no. 4, Oct., 1900, p. [123]-128. 4 diagrs. 1 plate. 1 chart. Sm. WB.

Tafel 1. Photogrammetrische rekonstruktion nach ballonaufnahme.

154 Finsterwalder, Sebastian.

Die topographische verwertung von ballonaufnahmen. Illus. aer. M. no. 1, Jan., 1900, p. 1-5. 5 figs. Sm.

155 Flemer, John Adolpus.

Photographic surveying in the United States Coast and Geodetic Survey. By J. A. Flemer, Topographer in Coast and Geodetic Survey, Washington. Int. Arch. P. Band ii, heft 2. Oct., 1910, p. 124-128, incl. 3 outline figs.

156 Franzoesische Kolonial-Kartographie.

Petermanns M. v. 56, pt. 1. No. 1, Jan., 1910, p. 157. 280 words.

Signed: Hk: LC. (G1P3, v. 56-1.)

157 Girard, Aime.

Laussedat's arbeiten in bezug auf die anwendung der photographie zur aufnahme von plänen. Photog. A. 6. band. Jhrg., 1865, p. 316-322. PO.

From Journal des débats et bulletin de la Société française de photographie, Paris, Mars, 1865.

158 Haerpfer, A.

Gewichtsbestimmungen in der photogrammetrie. Von privatdozent dr. A. Haerpfer in Prag. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 8-26, incl. diagrs.

159 [Hafferl, F.]

Das teleobjektiv und seine verwendbarkeit zu photogrammetrischen aufnahmen. Zeitsch. verm. Band xxi, heft 21. 1. Nov., 1892, p. 585-603, incl. diagrs., tables.

Signed: F. Hafferl, Ingenieur, Wien, im März 1892.

"Berichtigung," ibid., heft 24. 15 Dec., 1892, p. 662.

Signed: Hafferl, Ingenieur, Wien. im Nov., 1892. CG.

160 Hammer, E.

Scheimpflug's vorschläge zur beschleunigung und verbilligung der kolonial-vermessungen durch die photokarte. Von prof. Dr. E. Hammer. Petermanns M. v. 57, pt. 2, no. 7, Juli, 1911, p. 34-35. LC. (G1P3, v. 57-2.)

161 HELBRONNER, PAUL.

La phototopographie et la photogrammétrie. Applications aux levés des pays de montagnes. Par Paul Helbronner, Ancien élève de l'École Polytechnique, docteur ès sciences mathématiques. Genie C. 32e année, t. lx, 1er semestre, no. 19, whole no. 1552. 9 mars, 1912. Figs. 1-7.

ES. LC. (TA 2 G3.)

Fig. 1. Diagr.—Fig. 2. Alidade olométrique, à laquelle peut être substitué la phototachéomètre Vallot. Fig. 3. Phototachéomètre Vallot, vu par l'avant. Fig. 4. Phototachéomtère Vallot, vu par l'arrière. Fig.5. Reproduction d'un cliché téléstéréoscopique pris par M. Helbronner. Fig. 6. Diagram. Fig. 7. Diagram.

162 HOUARD, GEORGES.

La cartographie aérienne. Par Georges Houard, Secrétaire général de la Ligne francaise du cerf-volant. In: Science V. t. xii, no. 33, juin-juillet, 1917, p. [35]-50, incl. port., maps, illus., diagr. AW. Monthly List, Sept., 1917, item 3.

Illustrations: Portrait, Le Colonel Laussedat.—View: La Dordogne au Bec d'Ambés et les trois iles de Bourg-Gironde. Photographie obtenu au moyen de cerfs-volants par M. Marc Pujo . . . prise à faible hauteur 450 m. environ . . . p. 38. Map: La région du Bec d'Ambés représentée par une ordinaire, p. 39.—Diagram: Principe du perspectographe, p. 40. Illustration: "Ces-clichés ont été pris à plus de 2500 m. de hauteur," p. 40.—"Les huit vues redressées au perspectographe et assémblées pour former une carte géographique, p. 41.—Map: Carte ordinaire de la région photographiée par le "Scheimpflug."—L'Appareil Scheimpflug à chambres multiples, p. 42.—Appareil Scheimpflug à huit chambres fixé à la nacelle d'un ballon libre, p. 43. —Le perspectographe pour le redressement photographique des clichés, p. 44.—Appareil Douchet pour la photographie à bord des aéroplanes, p. 45.—Vue schématique de l'appareil Douchet, p. 46.—Montage de l'appareil photographique Douchet dans le fuselage d'un avion, p. 47.—Fragment d'un film obtenu par l'appareil Douchet. après assemblage des photographiques successives, p. 48.—Intéressante photo aérienne prise à une très faible hauteur, p. 49.

163 HOUDAILLE.

Notice sur les résultats du concours d'objectifs à long foyer. Destiné au service de l'aérostation militaire. Houdaille, Chef de bataillon du génie. Rev. du G. M. 16e année, t. xxiii, 1er semestre. Avril, 1902, p. [325]-362, incl. diagrs. ES. LC. (UG1R4 v. 23.)

164 KAMMERER, G.

Aéro-photographie, photo-perpectographe et photocarte. Conq. L'Air. 1913.

165 KAMMERER, G.

Landvermessung aus der luft. Int. Arch P. v. iii, 1912, p. 196-225.

166 KLINGATSCH, A.

Die orientierung photographischer aufnahmen von demselben standpunkt Von prof. A. Klingatsch in Graz. Int. Arch P. Band 1, heft 2. Juli, 1908, p. 83-95.

167 KOHLSCHUETTER, E.

Die Scheimpflug-Kammerer'sche landvermessung von luftfahrzeugen aus. Von prof. dr. Kohlschuetter, Berlin-Wilmersdorf. Petermanns M. v. 60, pt. 1, no. 5, Mai, 1914 ,p. 272-274. LC. (G1P3, v. 60-1.)

168 LEMBERGER, OTTO.

Stereophotographic surveying. Eng. N. v. 69, no. 13, March 27, 1913, p. 602-612, incl. 18 figs. ES. LC. (TA1 E6, v. 69.)

At head of article: "Synopsis."—"A short history of the development of

photographic surveying in Europe with a few examples of photographic railway location and reconnaissance surveys, the theory of photogrammetry briefly explained; the invention of stereophotogrammetry, its theory and practice."

"A description of the instruments used in stereophotogrammetry, the stereomicrometer and the stereocomparator with examples of their practical use. A description of the stereo-autograph, which automatically draws a map while an operator manipulates the stereo-comparator, with examples of its uses and its possibilities."

169 LE MEE.

Construction d'une carte topographique au moyen de deux vues hyperstéréoscopiques prise en aéroplane. Par Le Mee. (Communication faite à la séance de la section "Laussedat" de la Société francaise de photographie à Paris.) Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 280-284, incl. diagrs.

170 MANDL, JULIUS.

Verwertung von photographischen aufnahmen aus dem luftballon. Von Julius Mandl, k. und k. Hauptmann des geniestabes, Lehrer am höheren genie-curse. Mittheil. G. A. G. xxix. jhrg., heft 3, 1898, p. 165-194. plates, 7, 8, (part fold). ES. LC. (U3 M7 v. 29, 1898.)

Contents.—Ermittelung von standpunkt und orientierung des apparates bei unbekannter objectivbrennweite und unbekannter lage der hauptachsen. (Problem der fünf punkte), p. 167. [Dasselbe], bei bekannter objectiv-brennweite und bekannter lage der hauptachsen, p. 179. Anhang, p. 181. Ebene gebilde, projectivische verwandschaft. Die involution, p. 187. Deck elemente, p. 191. Erzeugniss zweier projectivischer strahlenbüschel, p. 191. Kegelschnitte-büschel, p. 193.

171 MEYDENBAUER, A.

Ueber die anwendung der photographie zu architektur-und terrain aufnahmen. Zeitsch. B. 1867, p. 62-70, incl. diagrs. 1 fold. plate.

LC. (NA3 Z5.)

Treats on Photometrography and describes the "Pantoscop" invented by A. Busch, Rathenow.

172 MICHAUD, G.

Telephotography with infra red rays. By G. Michaud and J. F. Tristan. Brit. J. P. v. 62, no. 2855. Jan. 22, 1915, p. 55-56.

LC. (TR1B8, v. 62.) UG.

Reprinted from the Scientific American, N. Y.

173 MIKIEWICZ, LUCIAN.

Anwendung der photographie zu militärischen zwecken Von Lucian Mikiewicz, Lieut. des 9. Feld-Art.-regiments. Mittheil. G. A. G. vii. Jahrg., 1876. p. 621-636, incl. diagrs. LC. (U3 M7 v. 7.) ES.

MUEHLKAMPF, ALOIS PROCHASKA EDLER VON.

See Prochaska, Alois, edler von Mühlkampf.

174 [OREL, EDUARD VON.]

Autostereograph des k. und k. Oberleutnant Eduard v. Orel. Int. Arch. P. Band 1, heft 2. Juli, 1908, p. 135.

175 [OREL, EDUARD VON.]

Die photogrammetrie im dienste der militärischen landesaufnahme. [Vortrag im Wiener photokluo, Jan. 25, 1909], von k. und k. Oberleutnant des Militär-geographischen institutes in Wien, E. von Orel. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 56-57.

Relates to the "Autostereograph" constructed by von Orel.

176 [OREL, EDUARD VON.]

Ueber den stereo-autographen. Vortrag gehalten vor der k. k. Geographischen gesellschaft, Wien, am 13. Feb., 1911. Int. Arch. P. Band ii, heft 3. Juni, 1911, p. 233-236.

Signed: K. v. M.

177 [OREL, EDUARD VON.]

Ueber die praxis der stereophotogrammetrie. Vortrag des k. und k. Oberleutnant E. v. Orel, Feb. 19, 1909, im Deutschen polytechnischen vereine in Böhmen zu Prag. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 58.

See also heft 2, Oct., 1910, p. 129-130.

178 PAGANINI, LUIGI PIO.

Nuovi appunti di fototopografia e applicazione della fotogrammetria all' idrografia. Per Pio Paganini, Ex-ufficiale di Marina ingegnere all' Istituto geografico militare a Firenze. Riv. Mar. Anno xxvii, fascicolo iii, marzo, 1894, p. 335-337, incl. illus. diagrs. outline figs. ND.

With bibliographical foot-notes.

179 [PAGANINI, LUIGI PIO.]

Die photogrammetrie in Italien. (Nach einem in der "Rivista di topografia e catasto" vom jahr 1889, erschienenen aufsatz des ingenieurs am Königl. Italienischen militär-geographischen Institut L. P. Paganini, deutsch bearbeitet von Adolf Schepp zu Wiesbaden. Zeitsch. verm. Band xx, heft 3. 1. Feb., 1891, p. 65-83; heft 12. 15. Juni, 1891, p. 328-339, incl. diagrs.; band xxi, heft 3. 1. Feb., 1892, p. 65-85, incl. illus. diagrs. tables. CG.

180 PEZET.

De la restitution du plan au moyen de la téléphotographie en ballon. Par Pezet, capitaine du génie. Rev. du G. M. 20e année, t. xxxi. 1er semestre. Mai, 1916, p. [377]-420; juin, 1906, p. [473]-506, incl. illus. diagrs. plans. ES. LC. (UG1 R4, v. 31.)

Contents.—Historique, p. 378-379.—Conditions de la reconnaissance par la téléphotographie en ballon, p. 378-381. Chap. i. Restitution au moyen de deux épreuves photographiques, p. 381-387.—Relèvement de la position du centre optique, p. 387-395.—Détermination de la projection du centre optique sur la plaque, p. 395-400.—Opérations graphiques de la restitution, p. 400-405. Chap. ii. Restitution au moyen d'une seule photographie, p. 405-420. Opérations graphiques, p. 476. Détermination de la position du centre optique par la photographie, p. 476-484. Altigraphe, fig. 28, p. 484. Des photographies comportant plus d'un repère, p. 485-497. La téléphotographie à bord des dirigeables, p. 497-506.

181 LA PHOTOGRAMMETRIE AERIENNE.

Tech. Aer. no. 80, avril 15, 1913, p. 325-345.

182 PHOTOGRAPHIC SURVEYING FROM BALLOONS.

Eng. v. 89. Jan. 28, 1910. LC. (TA1 E55, v. 89.) ES.

An abstract of the above was published in: Engineering Magazine, N. Y., v. 39, no. 1. April, 1910, p. 110-112.

This is a description of a method of topographic surveying involving the use of dirigable balloons. The Scheimpflug camera is briefly explained and his proposals regarding surveying by balloons in the colonial possessions are reviewed.

183 PHOTOGRAPHIE MILITAIRE ET PHOTO-CARTOGRAPHIE.

Genie C. 2e année. t. xxi, no. 16. 20 août, 1892, p. 266-267.

Signed: G. M.

Heading: Variétés.

184 PHOTOGRAPHISCHE LANDESAUFNAHME VOM LUFTSCHIFF AUS.

D. Luftf. Z. Wien. v. xvii, no. 24. Nov. 26, 1913, p. 569-574. 12 halftones. WB.

"Das material . . . verdanken wir . . . Dr. Karl Scheimpflug and ingenieur G. Kammerer . . ."

Fig. 1. Universal-photoperspektograph. Fig. 2. Photoperspektograph, model ii. Fig. 3. [Diagram]: Schematische darstellung des photoperspektographen. Fig. 4. Ballonkorb mit panorama-apparat. Fig. 5. Achtfacher panorama-apparat von unten gesehen. Fig. 6. Der apparat an dem lenkballon "Austria" montiert. Fig. 7. Originalaufnahme vom Maria-Joseph-Park von der "Austria" aus 800 m. höhe in voller fahrt. Fig. 8. Transformation zur aufnahme fig. 7.—Fig. 9. Originalaufnahme aus dem freiballon. Jedersee bei Wien, aus 960 m. höhe. Fig. 10. Transformation zur aufnahme, fig. 9.—Fig. 11. Gesamtaufnahme von Pullach a. Isar bei München aus 300 m. höhe.—Fig. 12. Schichtenplan.

185 PILLET, F. J.

Note concernant la construction d'un cerf-volant pour recherches scientifiques, explorations atmosphériques et relevés photographiques. Par F. J. Pillet, Ingénieur des arts et manufactures. Aer. 34e année, no. 6. Juin, 1901, p. 131-140, incl. 1 plate of 6 figs. Sm.

186 PIZZIGHELLI, JOSEF.

Die photogrammetrie. Von Josef Pizzighelli, Hauptmann im 2. Genieregimente. Mittheil G. A. G. Jhrg. xv, 1884, p. 280-288; 320-332, incl. diagrs. ES. LC. (U3M7, v. 15.)

"Benützte quellen," p. 332.

Contains also bibliographical foot-notes.

187 LA PLANCHETTE TOPOGRAPHIQUE MONTICOLO.

(Corps des mines, d'Italie). Genie C. 32e année. 1er semestre, v. 60, no. 15. 10 février, 1912, p. 280. LC. (TA2 G3, v. 60.)

188 POLLACK, VINCENZ.

Die photographische terrainaufnahme. (Photogrammetrie oder bildmesskunst.) Mit besonderer berücksichtigung der arbeiten in Steiermark und des dabei verwendeten instrumentes. Von Vincenz Pollack, Oberingenieur der k. k. General-direktion der oesterreichischen staatsbahnen. Centralbl. F. 17. jhrg., 7 heft. July, 1891, p. 289-303, incl. illus. diagrs. FS.

189 PROCHASKA, ALOIS, ELDER VON MUEHLKAMPF.

Oberleutnant von Orels stereoautograph. Von Alois Prochaska, edler von Mühlkampf, k. und k. Major des geniestabes, lehrer am höheren geniekurse. Mittheil. G. A. G. xlii. jhrg., heft 5. 1911, p. 429-443, incl. diagrs. Plate no. 11. ES. LC. (U3 M7, v, 42, 1911.)

"Anmerkung," p. 443, contains a brief review of the work and experiments of Eduard von Orel with his "Stereoautograph." Signed: Die Redaktion.

190 PROF. DR. A. SPRUNG, *i. e.* ADOLF FRIEDRICH RICHARD.

[Memorial.] Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 55-56.

At head: "Kleine mitteilungen."

Sprung was born June 5, 1848 at Kleinow near Perleberg, Brandenburg, Germany, + Jan. 16, 1909, at Potsdam.

[His writings]: p. 55-56.

Sprung has invented a number of meteorological instruments, and his writings are in relation to photogrammetry applied for meteorological observations.

191 PUJON, TH.

Photographische goniometrie. Von Th. Pujon und Th. Fourcade. Photog. Cor. Gerold's sohn, 1865, p. 156.

192 PULFRICH, CARL.

Das stereo-mikrometer, ein apparat zur demonstration der wirkungsweise der stereo-komparators. Von Dr. C. Pulfrich, Jena. Int. Arch. P. Band ii, heft 3. Juni, 1911, p. [149]-158, incl. illus., diagrs., tables.

Illustrations: Das stereo-micrometer. 2. Versuchsanordnung. 3. Stereo-komparator, model D. 4. Theorie einer stereo-photogrammetrischen aufnahme. 5. Das wandern der marke. 6. Parallaxe . . . 7. Das wandern des raumbildes. 8. Das . . . erhaltene photographische bild. Originalplan 1:10000, reduziert 1:23000.

193 PULFRICH, CARL.

Ueber den gebrauch der von mir angegebenen hilfsmittel für die kartierung bei stereophotogrammetrischen aufnahmen. Von dr. C. Pulfrich, Jena. Int. Arch. P. Band ii, heft 2. Oct., 1910, p. 75-79 incl. diagrs.

194 RANZA, ATTILIO.

Fototopografia e fotogrammetria aerea. Nuovo metodo pel rilevamento topografico di estese zone terreno. Ing. Attilio Ranza, tenente del genio. Riv. Art. G. xxiv. annata. v. iii, luglio-agosto, 1907, p. [5]-33; v. iv, ottobre, 1907, p. 76-96, incl. diagrs. 16 fold. plates. CA.

Plates show instruments, methods, also balloons, etc., and views taken.

This paper, and the book developed from it, are very highly recommended in: Hildebrandt's book, and in various professional journals.

195 SACONNEY, JACQUES THEODORE.

Conseils pratique de photo-topographie aérienne. Par J. Th. Saconney, capitaine de génie à Paris. Int. Arch P. Band 2, heft 3. Juni, 1911, p. 188-215, incl. illus. diagrs.

1ère ptie. Elévation de l'appareil photographique. Emploi des ballonnets et des cerfs-volants. 2éme ptie. Exécution des clichés. Suspension d'appareil. Pointage et dèclenchement. Chambre photographique. Suspensions. 3e ptie. Utilisation de la photographie aérienne pour les levers. Pratique des opérations de restitution. 2. Détermination de la position des deux stations et orientation des faisceaux. 3. Lever de la planimétrie. 4. Nivellement.

196 SACONNEY, JACQUES THEODORE.

Problème de métrophotographie. Rev. du G. M. 20e année. t. xxxii. 2e semestre, Nov., 1906, p. 499-506, incl. diagrs.

ES. LC. (UG1 R4, v. 32.)

Reviewed by Th. Scheimpflug, in: Internat. archiv für photogrammetrie, Juli, 1908, p. 146-147.

197 SACONNEY, JACQUES THEODORE.

Reconnaissances photographiques militaires à terre, en mer et en ballon. Par J. Th. Saconney, . . . Rev. du G. M. xxie année, t. xxxiii. 1er semestre. Février, 1907, p. [143]-160; avril, 1907, p. [329]-362; mai, 1907, p. [423]-468; juin, 1907, p. [543]-573; (à surivre), incl. diagrs. illus.

LC. (UG1R4, v. 33.) ES.

Reconnaissances par téléphotographie, p. 149.—Appareil téléphotographiques, p. 151; 333; 427; 547.—Téléphote de MM. Vautier et Dufour, fig. 9, p. 152.—Cylindrographe, p. 155.—Périgraphe, p. 156.—Téléobjectif Zeiss. fig. 15, p. 334.—Phototachéomètre Vallot, fig. 21, 18, p. 336-338.—Photogrammètre Deville, fig. 20, 21, p. 338.—Objectif Hermagis, fig. 39, p. 428.—Objectif Tessar, fig. 40, 41, p. 428.—Reconnaissances par cerfs-volants, p. 431-437; 439-449.—Appareil "Cailletet." à neuf chambres, fig. 47, p. 435.—Appareil Thilé, fig. 48, p. 436.—Reconnaissances par ballon captif. En cerf-volant, p. 450.—Reconnaissances sans carte p. 464.—Reconnaissances en mer. p. 543-562.—Appareils telephotographi-

ques, p. 547.—Cylindrographe, fig. 68, p. 548; 554-556.—Reconnaissances maritimes par cerfs-volants, p. 562-568.—Appareil photographique, p. 566.

The above articles are reviewed by Captain Th. Scheimpflug, in: Internationales archiv für photogrammetrie, Wien. Juli 1908, p. 141-145.

198 SANTARELLI, GIORGIO.

Il telegoniometro Fiske e alcune recenti esperienze su di esso. Ing. Giorgio Santarelli, Elettricista nella regia marina. Riv Mar. Anno xxvii. Terzo trimestre, luglio 1894, p. 41-54, incl. tables. 2 plates of 6 figs. ND.

199 SCHEIMPFLUG, KARL.

Photographische landesaufnahme vom luftschiff aus. Von Dr. Karl Scheimpflug und G. Kammerer. D. Luftf. Z. B. Jhrg. xvii, no. 24, Nov. 26, 1913, p. 569-574. 12 half-tones and outline cuts.

LC. (TL503 D4, v. 17.)

Fig. 1. Universal-photo-perspektograph. Fig. 2. Photo-perspektograph, model 12. Fig. 3. Schematische darstellung des photo-perspektographen. Fig. 4. Ballonkorb mit panorama-apparat. Fig. 5. Achtfacher panorama-apparat von unten gesehen. Fig. 6. Der apparat an dem lenkballon "Austria" montiert. Fig. 7. Original aufnahme von Maria Joseph Park von der "Austria" aus, 800 m. höhe in voller fahrt. Fig. 8. Transformation zur aufnahme. Fig. 9. Originalaufnahme aus dem freiballon. Jedlersee bei Wien aus 960 m. höhe. Fig. 10. Transformation zur aufnahme fig. 9. Fig. 11. Gesamtaufnahme von Pullach an der Iser, bei München aus 300 m. höhe. Fig. 12. Schichtenplan.

200 SCHEIMPFLUG, THEODOR.

Ergebniss der arbeiten 1907 zur terrain-aufnahme vom ballon (''Helios''). Wien. L. Z. vii. Jhrg., no. 3, März, 1908, p. 51-52. Sm.

201 SCHEIMPFLUG, THEODOR.

Hauptmann Scheimpflugs ballonfahrten zum zwecke photogrammetrischer terrainaufnahmen. [By himself.] Int. Arch. P. Band 1, heft 1. März, 1908, p. 72-74.

202 SCHEIMPFLUG, THEODOR.

Ueber oesterreichsche versuche, drachen-photogramme zu erhalten und kartographisch zu verwerten, und deren bisherigen resultate. Illus. aer. M. viii. jhrg., 3. heft. März, 1904, p. 88-96. 5 figs. Sm.

203 SCHEIMPFLUG, THEODOR.

Ueber orientierung von ballonaufnahmen. Von Hauptmann Theodor Scheimpflug in Wien. Vortrag, gehalten in der monatsversammlung der Photogrammetrischen gesellschaft in Wien, am 15. april 1909. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 34-54, incl. 33 outline figs. (diagrs.).

"Zur konstruktion des auf-und grundrisses des durch eine photographie repràsentierten strahlenbüschels auf dem bilde (figs. 5, 6, 7, 8,) "p. 50.—Details der Finsterwalderschen methode, p. 50-52.—Erläuterung der methode Saconneys, ballonaufnahmen direkt auf grund von drei punkten zu orientiren, p. 52-54."

204 SOME NOTES ON THE FOCAL-PLANE SHUTTER.

Brit. J. P. v. 62, no. 2888. 10 Sept., 1915, p. 586-597.

LC. (TR1B8, v. 62.)

Treats on the efficiency of the focal shutter.

205 STEEB, CHRISTIAN, FREIHERR VON.

Der stereoautograph und die kartographie. Von Christian freiherrn von Steeb, k. k. Feldzeugmeister d. R. Petermanns M. 57. jhrg. 2. hälfte, heft 2. Aug., 1911, p. 92-94. LC. (G1P43, v. 57-2.)

The same, reprinted in: Mittheil. G. A. G. xliii. jhrg., heft 11, p. 995-1002.

LC. (U3M7, v. 42.)

206 STOLZE, F.
Aufnahme der Freitags-Moschee in Schiraz. Photog. Woch. 7. Jhrg., 1881, p. 133-136. PO.

207 STOLZE, F.
Die photogrammetrie in Halberstadt. Photog. Woch. 8. Jhrg., 1882, p. 282-284; 289-290; 297-299. PO.

208 STOLZE, F.
Der photographische theodolit und sein gebrauch zur aufnahme von bauwerken und specialkarten. Photog. Woch. 7. Jhrg., 1881, p. 44-45, incl. diagrs. PO.

209 STOLZE, F.
Ueber die praktische ausführung photogrammetrischer aufnahmen. Photog. Woch. 7. Jhrg., 1881, p. 141-143; 149-151; 158-160; 166-168. PO.

210 TARVIDO, CESARE.
La fotografia dall' aerostato nelle sue applicazioni in topografia. Cesare Tarvido, capitano del genio. Riv. Art. G. xxvii annata, v. ii, giugno, 1910, p. 381-414. 3 plates (part fold).
ES. LC. (U4R6, v. 27.)

Cambiamento del quardro.—Determinazione degli elementi di una prospettiva.—Determinazione dell' altitudine dei punti rappresentati.—Determinazione dell' altezza della stazione.—Applicazioni.—Conclusione.

211 TARVIDO, CESARE.
Fotografia e telefotografia militare dall' aeroplano e dal dirigible. Per Cesare Tarvido, Capitano del genio. Riv. Art. G. xxix (51a) annata, v. ii. Aprille, 1912, p. 145-152. LC. (U4R6.) ES.

This is an abstract of the author's book published under the title: Manuale di fotografia . . . which see. no. 85.

212 TELEPHOTOGRAPHIE.
Photo-Min. v. iii, no. 26, May, 1901, p. [49]-84, incl. diagrs. 5 plates.
ES. LC. (TR1 P67, v. 3.)

"Books," p. 84.

213 TELESCOPIO TELEFOTOAPPARATO.
Riv. Art. G. v. 4, xxxiv (56a) annata. Oct.-Nov., 1917, p. 140-143.

214 THIELE, R.
Hauptmann Uljanins verfahren zur schnellen distanz-bestimmung aus aerophotographischen aufnahmen. Von R. Thiele in Moskau. Int. Arch. P. Band ii, heft 1. Juni, 1909, p. 26-34, incl. diagrs.

215 THIELE, R.
Métrophotographie aérienne à l'aide de mon Autopanoramographe. Par R. Thiele à Moscou. Int. Arch. P. März, 1908, p. 35-45, incl. illus., map, diagrs. 1 plate, (map).

216 THIELE, R.
Photogrammetrische arbeiten in Russland. Von R. Thiele, in Moskau. Int. Arch. P. Band 1, heft 3. Nov., 1908, p. 174-197, incl. illus. 1 plate (part fold).

217 TORROJA, JOSE MARIA.
Notes historiques sur la photogrammétrie en Espagne, avec un résumé de la mémoire presentée par le colonel A. Laussedat à l'Académie royale

des sciences de Madrid l'an 1863. Par José Maria Torroja, Docteur des sciences exactes, ingénieur des ponts et chaussées à Madrid. Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 249-276, incl. illus., diagrs. 2 maps, 2 plates.

Contents.—1ere Pte. Investigations théoriques. Mémoire presenté par M. A. Laussedat à l'Académie royale des sciences de Madrid, l'an 1863, p. 250-257. ii. Théorie géométrique de la photogrammétrie, par le general Antonio Terrero, Madrid, 1862, p. 257-261. iii. Mémoire officiel du major d'état major, M. Pedro de Zea, chef de la Commission envoyée à l'étranger pour étudier les applications de la photographie à la topographie (8 mai 1863), p. 261-262. iv. Topographie photographique, c'est-à-dire, application de la photographie à la levée de plans par MM. Ciriaco de Iriarte et Leandro Navarro, ingénieurs agronomes, p. 262-263. v. "Photo-topographie pratique" par le lieutenant colonel d'état major M. Alejandro Más y Zaldua, p. 263-264. vi. D'autres travaux théoriques sur la photogrammétrie, p. 264-265. iime ptie. Levées photogrammétriques realisées en Espagne. i. Brigade topographique du génie militaire, p. 265-266. ii. État major de l'armée. Levée phototachéométrique de la ville de Ribds (Gerone) et de ses alentours par le lieut.-col. M. Alejandro Más y Zaldua, p. 266-273. iii. Institut géographique et statistique, p. 273-274. iv. Photographies obtenues en ballon, p. 274-275. v. Travaux photogrammétriques divers, p. 275-276.

This very interesting historical summary contains many bibliographical references throughout the various papers, as well as cuts showing instruments applied.

218 Torroja, Jose Maria.

Le problème général de la photogrammétrie et de la perspective en coordonnées projectives. Par José Maria Torroja, docteur des sciences à Madrid. Int. Arch. P. Band 1, heft 4. Feb., 1909, p. 256-263, incl. diagrs.

219 Torroja, Jose Maria.

Sur une question de priorité à propos du "Théorème de Hauck." Par le dr. Joseph M. Torroja à Madrid. Int. Arch. P. Band ii, heft 2. Oct., 1910, p. 103-111, incl. diagrs.

220 Tronquoy, C.

Bemerkung über die "Planchette photographique" von A. Chevallier. Photog. Cor., 1867, p. 180.

221 Trunk.

Planimeter, mess-und rechenmaschine. Polyt. Centralbl. Neue folge, 1868, p. 202.

222 Tschamler, Ignaz.

Aus der praxis der stereophotogrammetrie. Von Ignaz Tschamler, tech. oberoffizial des k. und k. Militär-geographischen institutes in Wien. Int. Arch. P. Band ii, heft 4. Oct., 1911, p. 276-280, incl. diagrs.

i. Umwandlung verschwenkter bilder in normale. ii. Stereoskopische distanz-(höhen)-messung bei ungleich höhen ballonorten.

223 Verwendung der Photographie bei Topographischen aufnahmen. Illus. aer. M. iv. jhrg., no. 4, 1900, p. 128-129. Sm.

Signed: K. v. B.

224 Wenz, Emile.

Chambre noir Wenz-Hermagis pour photogrammetrie aérienne. Int. Arch. P. Bd. 2, heft 3. Juni, 1911, p. 215-216.

225 Wheeler, Arthur O.

Notes on the field-work of photographic surveying as applied in Canada.

By Arthur O. Wheeler, F. R. G. S. topographer, Dept. of the Interior, Canada. Int. Arch. P. Band 1, heft 2. Juli, 1908, p. 95-104.

226 Williams, Dion.

Photography from aircraft. . . . [By Colonel Dion Williams, U. S. M. C.] Mar. C. Gaz. v. vii, no. 2. June, 1917, p. 95-103. 10 plates. ES.

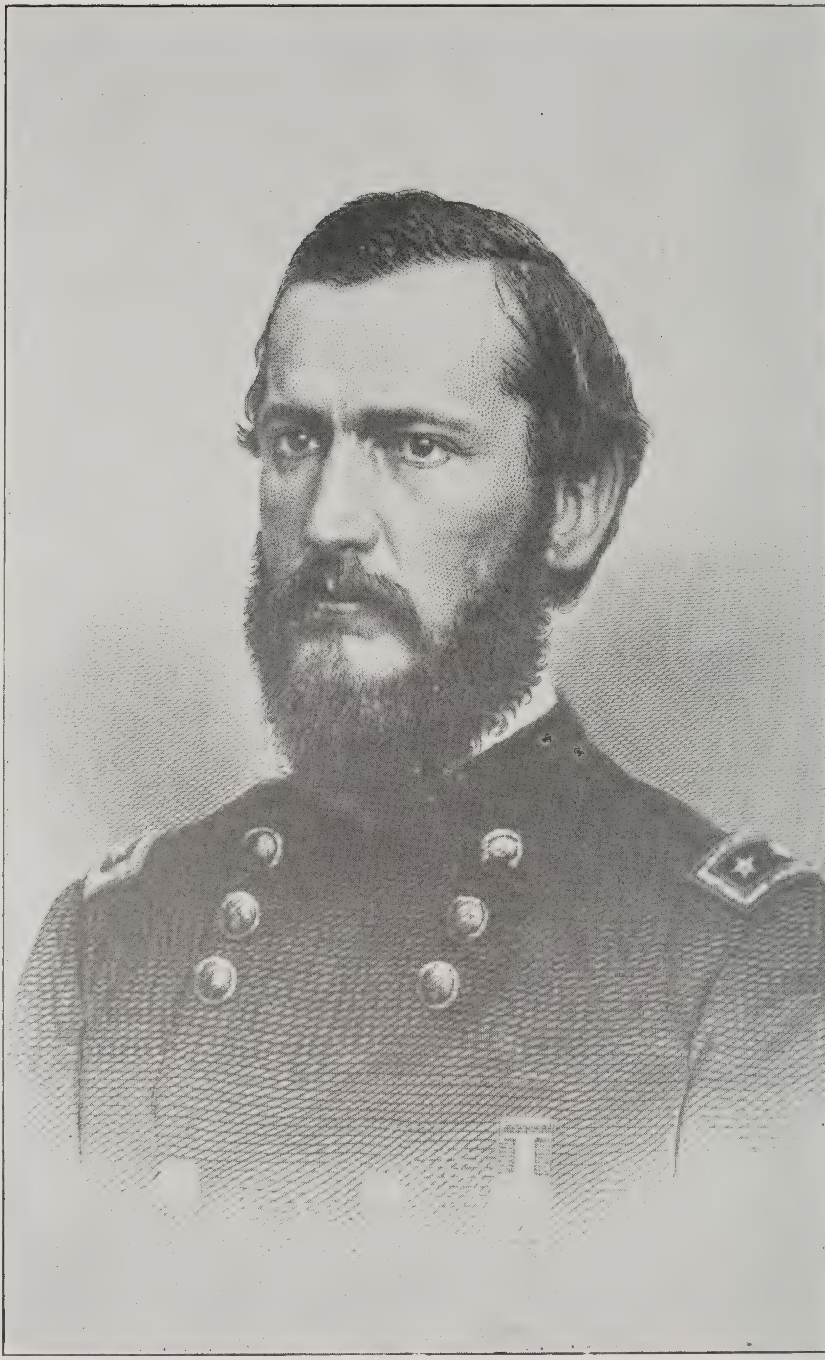
Illustrations show the Scheimpflug combination aerial camera.

227 Zuloaga, Angel Maria.

Aviación. Aerofotogrammetria. Por Angel Maria Zuloaga, Capitán de artilleria, Piloto aviador y aeronauta. Rev. C. Mil. año xvi, no. 181. Feb., 1916, p. 85-90, incl. 3 outline cuts; no. 182, marzo, 1916, p. 145-150 incl. 4 outline cuts. AW. Monthly list, June, 1916, item 379.

Perspectómetro angular.—Su constructión y empleo. Treats on the technics of aerial photography.

INDEX.



GENERAL GODFREY WEITZEL
FROM AN ENGRAVING BY A. H. RITCHIE

CONSTRUCTION OF CONCRETE LOCK IN HUDSON RIVER AT TROY, N. Y., 1916, IN CHARGE OF COL. W. M. BLACK, CORPS OF ENGINEERS

By

Maj. M. J. McDonough,[1]

Corps of Engineers.

Report on Foundations and Bonding, Lock Walls[2]

By

Mr. Willson Y. Stamper,

Minor Draftsman.

In preparing the foundations for the walls of the lock, excavation was carried down until solid rock was encountered. Upon this surface, which was cleared of all loose rock, the concrete was deposited without the use of anchor rods or other bonding. The rock surface was of sufficient roughness and such character as to make unnecessary the use of artificial bonding. A coat of mortar was worked over the surface before the first concrete was deposited.

Bond between vertical joints of the lock wall sections was secured by V-shaped keys, the area of the keyways being not less than 20 per cent of the total area of the joint. The keys were made of two pieces of 1 by 12 inch plank nailed together, and the design was adopted because the keys are easily made and removed. The different courses or lifts in which the sections were cast were bonded on the horizontal surfaces by a series of raised keys.

In the construction of the north and south guide walls, anchor rods were used to secure the walls against overturning or rupture by the impact of vessels, which may ultimately reach 3,000 tons burden. The south guide wall, which was of solid section, was anchored by 1-inch deformed bars, spaced about 1 foot on centers, along a line about 2 feet in from the lock chamber face of the wall. These rods were set into the rock about 4 feet, grouted with neat cement, and extended vertically to within a foot of the top of the guide wall.

[1]And others.

[2]Revised by Maj. M. J. McDonough, Corps of Engineers, U. S. A.; and Mr. D. A. Watt, Assistant Engineer.

The north guide consists of a series of piers and slabs with a continuous top course, extending the full length of the wall. This wall was secured by two sets of anchor rods, situated in each pier, grouted into the rock, and extending into the top course to within a foot of the top of the wall.

The set on the lock face of the wall consists of six vertical 1-inch deformed bars, spaced about 1½ feet on centers, and located about 1½ feet back from the face. The other set consists of four similar bars, set 2 feet on centers, and inclined to follow approximately the slope of the back of the wall.

Examples of similar anchoring of guide walls and of walls bounding a canal prism are to be found in some of the structures of the New York State Barge Canal, where the walls were high and without filling behind them. In the case of the Troy wall, investigation was made as to what thickness of wall would be needed to support by dead weight (or size) the side impact of a slow-moving 3,000-ton barge. On the assumption of no elasticity in the concrete, it was found that a moderately high wall struck near the top would have to be about 75 feet wide at the base, and if elastic concrete were assumed, no one could say reliably how far the assumption should be carried. As walls are in satisfactory service of more moderate base widths, it was decided to use customary designs and to reinforce the two structures with anchor rods as described.

Report on Lock Gates[1]

By

Mr. Frank P. Fifer,
Junior Engineer.

The gates are of the mitering, girder type, carrying the principal load as beams. They are built of steel, with single skin-plates, but have white oak quoin and toe posts. The quoin post swings on a cast-iron pivot, set in the concrete and is held at the top by an adjustable anchorage. The wooden quoin post bears directly on the concrete thrust wall. The details of these lock gates are shown in Figs. 1 to 8, inclusive.

[1]Revised by Maj. M. J. McDonough, Corps of Engineers, U. S. A.; and Mr. D. A. Watt, Assistant Engineer.

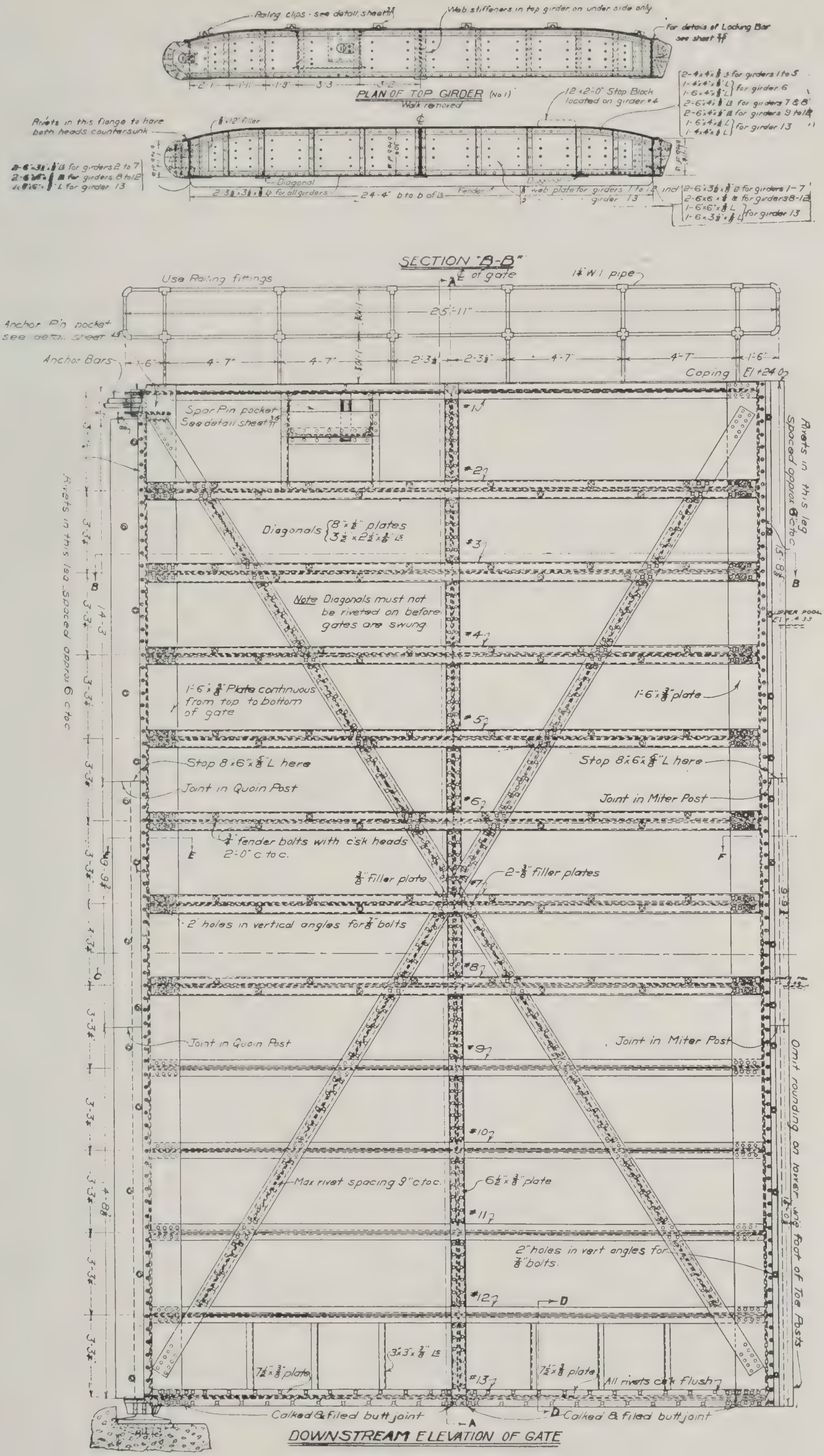

PLAN OF TOP GIRDER (No 1)
Walk removed
SECTION "B-B"
Use Railing fittings
Anchor Bars
Coping
Diagonals
Note Diagonals must not be riveted on before gates are swung.
Joint in Quoin Post
Joint in Miter Post
Max rivet spacing 9" c to c.
All rivets c'sk flush
Calked & filed butt joint
DOWNSTREAM ELEVATION OF GATE

Fig. 1.

Size. The lower gates are about 2 feet 7 inches deep, 26 feet 9 inches long and 40 feet high, and one leaf weighs about 87,000 pounds. The upper gates are of the same dimensions, except they are 26 feet high and one leaf weighs about 55,600 pounds.

Gates. The design of the gates was based on the assumptions and formula recommended by the Board of Engineers on Deep Waterways, a full exposition of which is published in Part I of its report for 1900. The lower portions were designed for the alternate conditions of resting against the miter sills and of not touching them.

Pintle and Shoe. The pintle and bed plate shown in Fig. 8 are of the customary one piece design with a base plate beneath, on which the pintle could slide should any obstruction get between the gate and the sill or between the quoin post and the wall. Another arrangement to permit sliding is provided in the design of the shoe which has the recess or cup in the shoe, which fits over the pintle, elongated 3 or 4 inches. For gates of about the size given above, it is not believed necessary to make the pintle or bearing part of the shoe of special material, for it is known that chilled cast-iron surfaces will last under long service without much wear.

Power for Operating. The amount of power necessary to operate the gates was determined from experiments made on a similar set of gates on the New York State Barge Canal. Fig. 9 shows the horsepower curve of that set for different conditions of operation. The length of time of operation considered most suitable is 45 seconds. The maximum horsepower required during one complete operation in 45 seconds is about 4½ horsepower. The starting load on the spar was found to be about 11,000 pounds; the load during mid-travel was 3,000 pounds to 8,000 pounds. The 3,000-pound load was for a 64-second operation and the 8,000 was for a 31-second operation.

Operating Machinery. The machinery to be installed for the permanent operation of the lock gates, as shown in outline in Fig. 10, will be of the spar and bull wheel type, similar to that used on the Panama and Keokuk locks. The point of attaching the spar is one-third the gate's length from the axis of rotation. The spar, which consists of two channels back to back, will contain an adjustable spring or shock absorber, which will permit the length of the spar to be adjusted and the compression in the spring varied. The spar will be actuated by a bull wheel whose

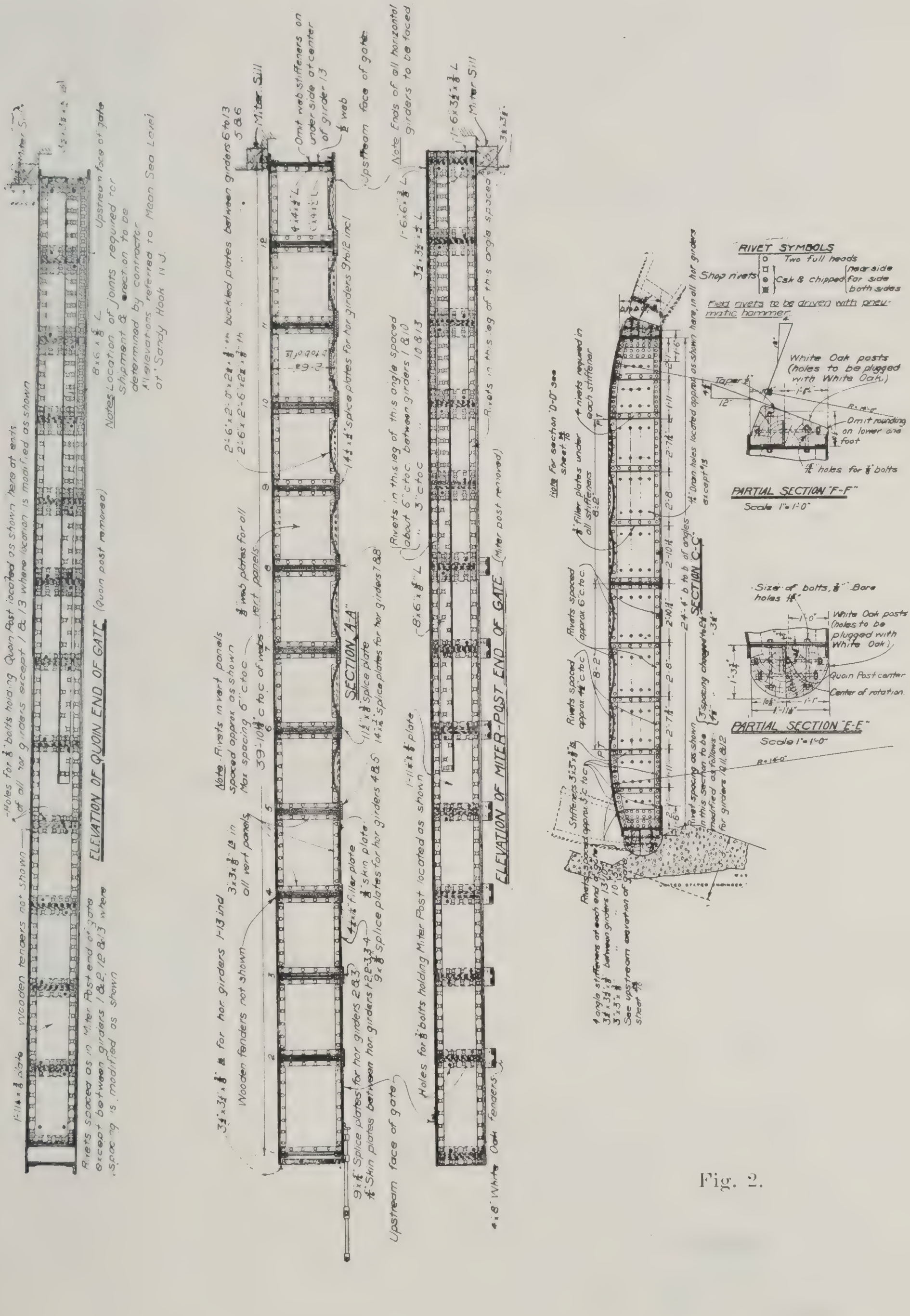

ELEVATION OF QUOIN END OF GATE (Quoin post removed)
SECTION "A-A"
ELEVATION OF MITER-POST END OF GATE (Miter post removed)
SECTION C-C
RIVET SYMBOLS
PARTIAL SECTION "F-F"
Scale 1"=1'-0"
PARTIAL SECTION "E-E"
Scale 1"=1'-0"

Fig. 2.

diameter is to be 10 feet 4 inches. The spar will be attached to the wheel, so that when the gate is fully closed or opened, the line of thrust of the spar will pass directly over the axis of rotation of the bull wheel. By this means the gate leaf will be automatically locked in a mitered or closed position and also when in the fully open position. The power for operating the bull wheel will be obtained from an air jack of 18-inch diameter and 6-foot stroke, the air being supplied at 100 pounds pressure. The piston of this cylinder carries a rack which transmits the power through one set of gears to the circumference of the bull wheel. Hand power for operating the gates will also be provided and will consist of a hand operated lever, which turns a spur gear. Arrangements will be made so that the air power cannot be applied when the hand lever is in place.

Temporary Operating Machinery. It was necessary to use the lock during a part of the navigation season of 1915 before the installation of the permanent machinery, and consequently a temporary rig had to be installed. This, as shown in Fig. 11, consisted of 10 by 10 inch timber spars operated by single lines from hoisting engines. This rig proved very effective.

General Operation of the Lock. The original drawings of the lock showed a control stand on each wall at each gate section. It was intended that all the valves and gates at a particular gate section could be operated from either control stand at that gate section. The necessity for this duplicate installation, however, appeared doubtful. The plans were accordingly changed so that all the machinery on both walls at one gate section could be operated from a single control stand placed on the river wall at that gate section. Accordingly, a plan was drawn up for this single wall operation and an estimate received for the necessary materials for its installation, which included three control stands, twelve solenoid air valves that would operate as well submerged as they would out of water, and all other necessary parts with the exception of the lead covered cable required to run from gate section to gate section. In connection with this single wall or remote control, there was designed an electrical interlocking of gates and valves. This interlocking system is arranged so that no valves can be opened unless the lock gates are either mitered or fully open. And, conversely, the lock gates cannot be started from closed or open position unless the valves are closed. The purpose of the interlocking is to forestall the possibility of accident by the premature opening of the

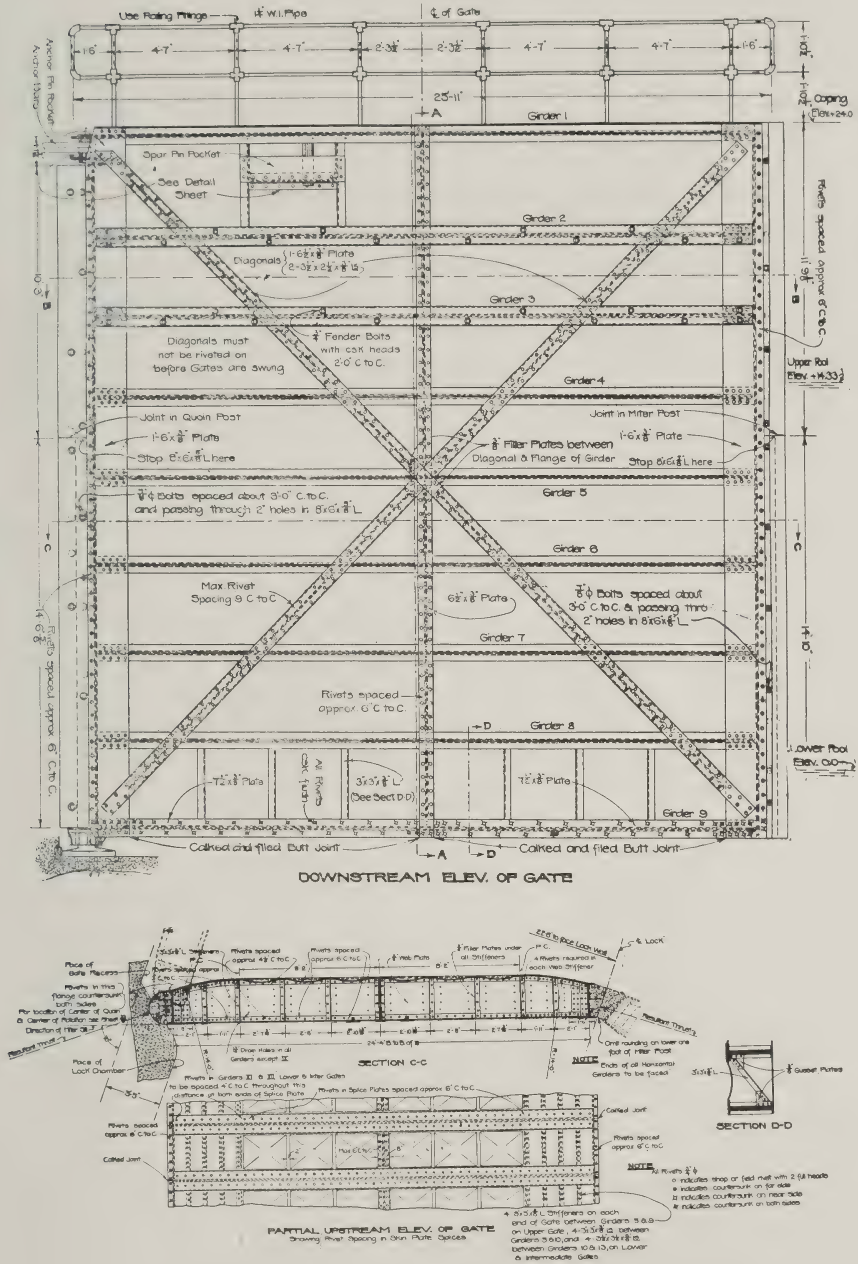

Use Railing Fittings
1½" W.I. Pipe
℄ of Gate
Anchor Pin Pocket
Anchor Bars
Coping
Elev.+24.0
Girder 1
Spar Pin Pocket
See Detail Sheet
Girder 2
Diagonals 1-6½"x⅜" Plate 2-3½"x2½"x⅜" Ls
Girder 3
¾" Fender Bolts with csk heads 2'-0" C to C.
Diagonals must not be riveted on before Gates are swung
Rivets spaced approx 6" C to C
Upper Pool Elev.+14.33½
Girder 4
Joint in Quoin Post
Joint in Miter Post
1'-6"x⅜" Plate
⅜" Filler Plates between Diagonal & Flange of Girder
Stop 8"x6"x⅜" L here
Girder 5
⅞"ɸ Bolts spaced about 3'-0" C. to C. and passing through 2" holes in 8"x6"x⅜" L
Girder 6
Max. Rivet Spacing 9" C to C
6½"x⅜" Plate
Girder 7
Rivets spaced approx. 6" C to C.
Girder 8
Lower Pool Elev. 0.0
7½"x⅜" Plate
All Rivets csk flush
3"x3"x⅜" L (See Sect. D-D)
Girder 9
Calked and filed Butt Joint
DOWNSTREAM ELEV. OF GATE
SECTION C-C
Face of Gate Recess
Face of Lock Chamber
Resultant Thrust
℄ Lock
NOTE Ends of all Horizontal Girders to be faced
SECTION D-D
PARTIAL UPSTREAM ELEV. OF GATE
Showing Rivet Spacing in Skin Plate Splices
Calked Joint
Rivets spaced approx 6" C to C
NOTE All Rivets ⅞"ɸ

Fig. 3.

valve. Such an accident actually happened on the Barge Canal in the spring of 1915. The cost of the remote control, including all signal lights showing the condition of the lock gates and valves, is $3,395. The cost of the interlocking which would be installed with this system would be that of adding two No. 12 B. & S. wires to the lead-covered cable that runs around the lock; this cost is estimated not to exceed $600. The total cost would thus be about $4,000. As against the remote control and interlock, it may be stated that experience shows a man to be needed on each wall for the purpose of handling lines, preventing drift from collecting behind the gates, etc. The remote control is somewhat complicated. The accident that the interlock is designed to forestall is an extremely rare one, the risk of which is very small. On the whole, therefore, it is believed that the cost of the interlock and remote control is not at present warranted by the results to be obtained. If experience shows remote control, or interlock, or both, to be necessary, the installation can be made at any subsequent time about as cheaply as it can now.

Contract. The contract for furnishing these gates, which were to be erected in place, was let to the King Bridge Company, Cleveland, Ohio, at the following prices: Structural steel 5.2 cents per pound; Cast iron, 5 cents per pound; Timber, $60 per 1,000 feet B. M.; Total estimated amount, $21,383.20 for three sets of gates (one upper, one intermediate and one lower set) erected in place.

The quantities were divided as follows:

	Total weight, 2 leaves, pounds		Ft. B. M. Timber
	Steel	Cast iron	
Upper gates	92,934	3,740	3,818
Intermediate gates	144,329	3,740	6,348
Lower gates	144,329	3,740	6,348
Grand total	381,592	11,220	16,514

Shop Erection. The gates were erected complete in the shop in a horizontal position with the skin plate on top. All the holes for the ¾-inch field rivets had been punched ⅝ inch and the gates were first bolted up securely with ½-inch bolts and then reamed out to 13/16-inch for the field riveting.

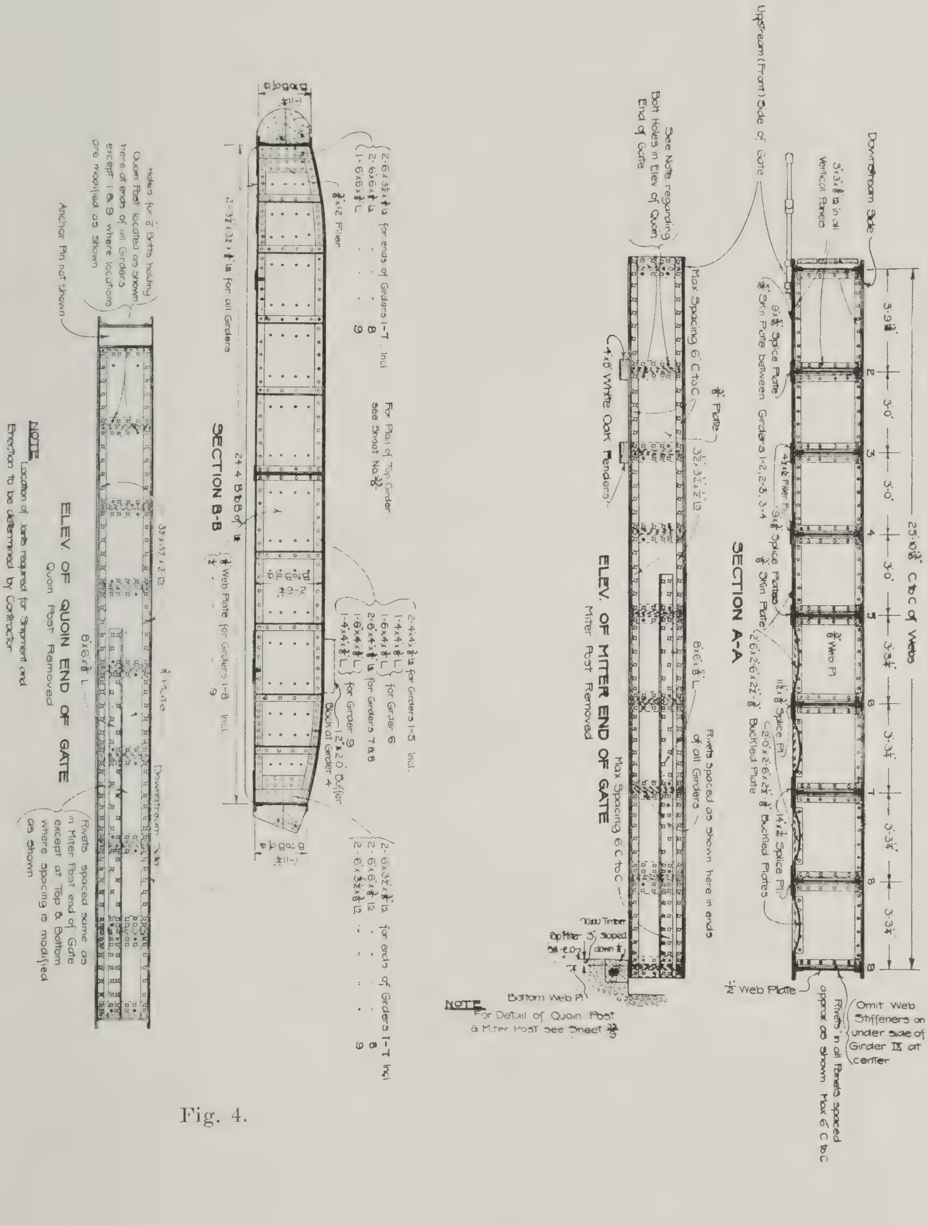

SECTION A-A
25'-0¾" C to C of Webs
Downstream Side
Upstream (Front) Side of Gate
½" Web Plate
Omit Web Stiffeners on under side of Girder IX at center
Rivets in all Panels spaced approx as shown Max 6" C to C
ELEV. OF MITER END OF GATE
Miter Post Removed
4x8 White Oak Fenders
Max Spacing 6" C to C
NOTE
For Detail of Quoin Post & Miter Post see Sheet
SECTION B-B
Block at Girder 4
ELEV. OF QUOIN END OF GATE
Quoin Post Removed
Anchor Pin not shown
NOTE
Location of Joints required for Shipment and Erection to be determined by Contractor

Fig. 4.

Field Erection. The upper set of gates was erected in place on the miter wall, the members being set up in the following order; first, the bottom girder was placed on the wall, then the two end vertical girders were placed with the lowest section of the middle vertical girder. The frame was then ready for the second horizontal girder. After all the horizontal girders were in place, the skin plate was placed, then the diagonals, and finally the diagonal braces on the bottom girder with other miscellaneous small parts.

The wooden quoin and miter posts were cut so as to allow ¼ inch fullness on each. After the gates were hung and mitered, several saw kerfs down and between the miter posts were made sufficient to allow the gates to come within ⅛ to ¼ inch of the sill at the miter. This clearance is taken up when the gates are loaded, allowing the gates to come against the sill.

Due to the fact that the intermediate and lower gate recesses were not ready and as it was most necessary to advance the work as much as possible, these two sets of gates were erected in a vertical position in the lock chamber just below the upper miter wall, as shown in Fig. 12, and afterwards moved into position as shown in Fig. 13. This moving was done by the contractor, for which he was paid extra. The total cost of the extra work was $1,415.15, but it is estimated that from two to three weeks' time was saved by not having to wait upon the gate erection after the gate masonry had been completed.

The gates were painted one coat of black "Elaterite" metal preservative paint in the shop and one coat of the same paint after erection in the field.

Conclusion.

Points of special interest which it would be advisable to modify in future constructions are as follows:

Rivet Spacing. The rivet spacing in the curved flanges at the ends of the girders should be made 3 or 4 inches instead of 6 inches, on account of the difficulty found in getting tight field rivets there. In some plates as much as 20 per cent of these field rivets had to be cut out and redriven in these flanges and splice plates. Erection bolts were placed in every other hole which made their spacing 12 inches, but this distance was too large, for it was extremely difficult to draw the plates together so that the rivets would be tight. With closer rivet spacing, this difficulty would be avoided. No special trouble was met with in

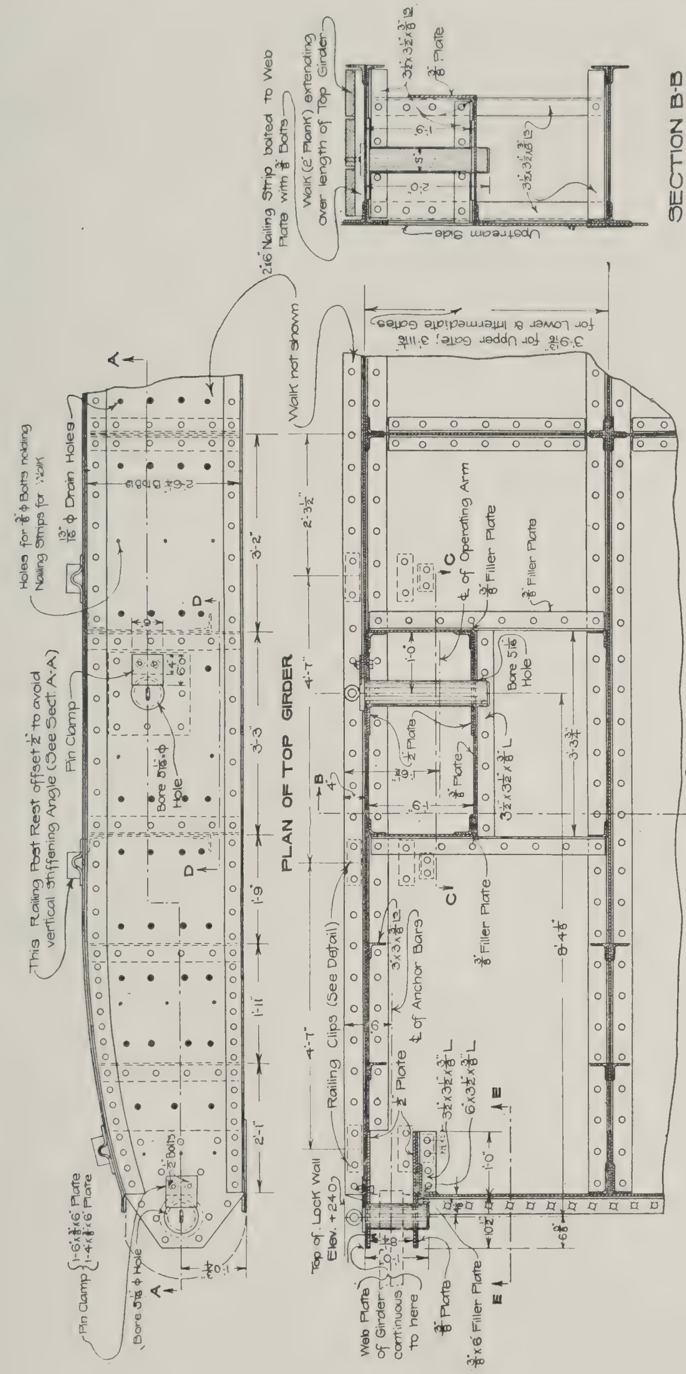

PLAN OF TOP GIRDER
SECTION A A
SECTION B-B
This Railing Post Rest offset ½" to avoid vertical Stiffening Angle (See Sect. A-A)
Holes for ⅜" φ Bolts holding Nailing Strips for Walk
13/16" φ Drain Holes
Pin Clamp
Bore 5 1/16" φ Hole
Walk not shown
2x6" Nailing Strip bolted to Web Plate with ⅜" Bolts
Walk (2" Plank) extending over length of Top Girder
Upstream Side
Railing Clips (See Detail)
℄ of Anchor Bars
℄ of Operating Arm
⅜" Filler Plate
Top of Lock Wall Elev. + 24.0
Web Plate of Girder continuous to here
3'-9 3/16" for Upper Gate; 3'-11 ⅛" for Lower & Intermediate Gates

Fig. 5.

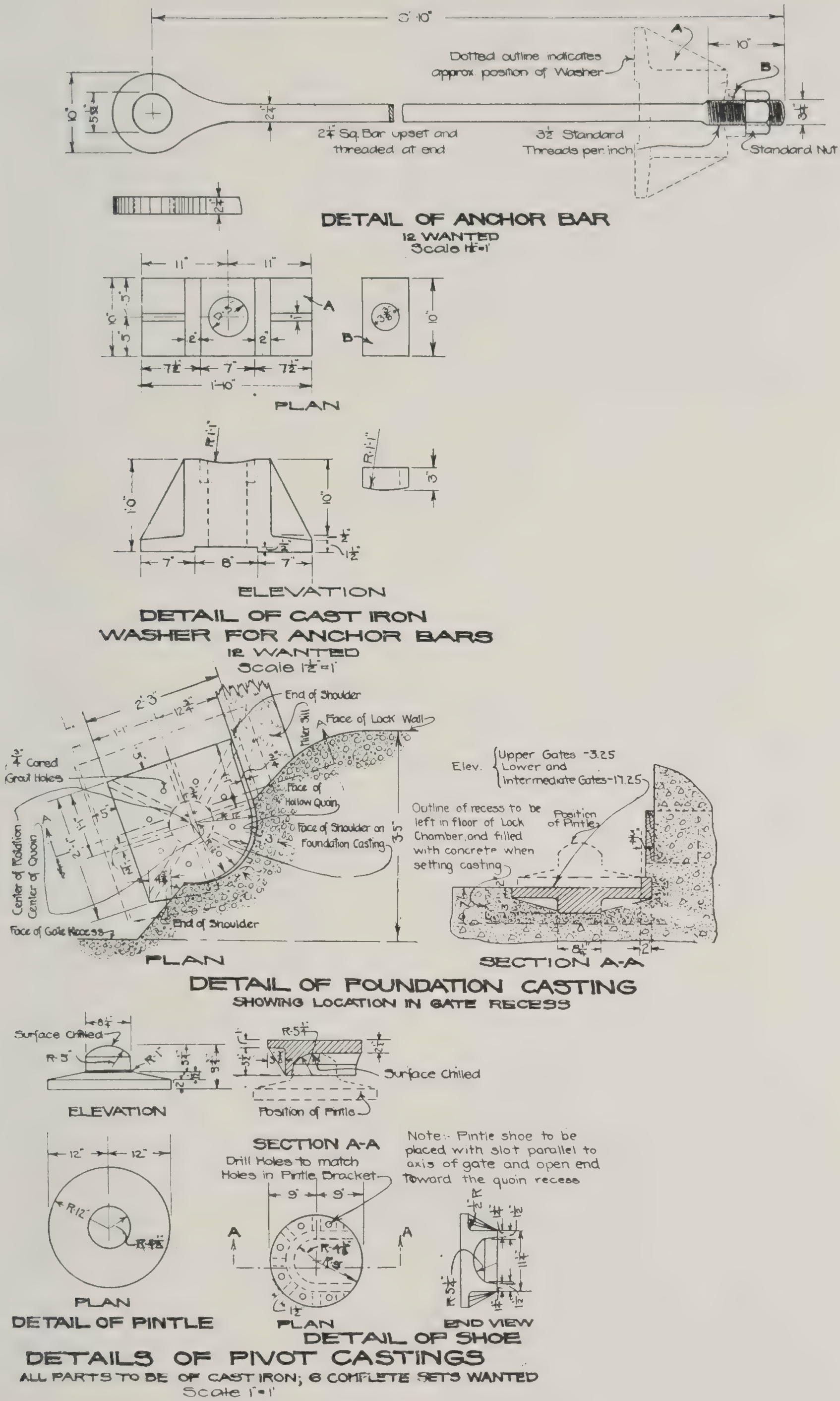
getting satisfactory field riveting along the 6-inch spacing of the straight portions of the flanges.

Hollow Quoin in Thrust Wall. No special lining or construction was used for the hollow quoins. A sheet-iron lining was placed for the concrete face on the inside of the wooden form, which was well braced. The wall was laid in about three lifts, and it was found difficult to secure the quoin form so that, after construction, the hollow quoin did not have to be plumbed and cut. The cost of this work was more than the cost of cast-iron lining plates would have been. On the other hand, experience with cast-iron quoins on the Barge Canal and other locks has shown that even with their use a similar difficulty in obtaining plumb and straight surfaces of contact is usually met with. Latest practice has been to set up the cast sections and grout them in place after the main mass of the concrete has been finished. A method of construction for the concrete quoin which is believed would prove more successful would be to leave in the concrete a small recess back of the finished line of the hollow quoin, placing anchor bolts throughout its length. These bolts would be used to secure a special form which would be placed after the monolith forms had been removed. The concrete of the quoin proper would then be poured without danger of the form moving.

Another method for the construction of concrete hollow quoins when wood is used for the quoin post on the gate would be to form the recess as described in the preceding paragraph, omitting the anchor bolts; the lock gates with the wooden quoin post attached and well greased would then be moved into place and hung in the mitered position. By placing closure strips from the wall to the wooden quoin post, the mortar to form the quoin could then be poured.

Setting Wooden Miter Sills. The upper set of sills were placed before the gates were hung and, in consequence, the gates were mitered and then fitted to the sills by the cut-and-try method. The other sills were placed after the gates were hung and mitered. The gates were forced into their mitered position and the sills were then wedged against the gates and grouted in position. This latter method of hanging the gates and placing the sills proved very satisfactory and the gates could be finished to the exact length proposed.

Center of Rotation. The center of rotation of the gates was, as is customary, placed well upstream of the center line so that the leaf swings free of the quoin as soon as it begins to move.



DETAIL OF ANCHOR BAR
12 WANTED
Scale 1½"=1'
Dotted outline indicates approx. position of Washer
2¼" Sq. Bar upset and threaded at end
3½ Standard Threads per inch
Standard Nut
PLAN
ELEVATION
DETAIL OF CAST IRON WASHER FOR ANCHOR BARS
12 WANTED
Scale 1½"=1'
End of Shoulder
Face of Lock Wall
¾" Cored Grout Holes
Face of Hollow Quoin
Face of Shoulder on Foundation Casting
Center of Rotation
Center of Quoin
Face of Gate Recess
Elev. Upper Gates -3.25
Lower and Intermediate Gates -17.25
Outline of recess to be left in floor of Lock Chamber and filled with concrete when setting casting
Position of Pintle
PLAN
SECTION A-A
DETAIL OF FOUNDATION CASTING
SHOWING LOCATION IN GATE RECESS
Surface Chilled
ELEVATION
Position of Pintle
SECTION A-A
Drill Holes to match Holes in Pintle Bracket
Note:- Pintle shoe to be placed with slot parallel to axis of gate and open end toward the quoin recess
PLAN
DETAIL OF PINTLE
PLAN
END VIEW
DETAIL OF SHOE
DETAILS OF PIVOT CASTINGS
ALL PARTS TO BE OF CAST IRON; 6 COMPLETE SETS WANTED
Scale 1"=1'

Fig. 6.

Painting. The paint on these gates has not proved entirely satisfactory as it has spealed off, particularly from around the rivet heads, allowing them to rust. The exact cause of this spealing off is not known; it may be due to the paint or to the surface of the steel not having been cleaned sufficiently before painting. However, before the first coat was applied in the shop, the surface was cleaned by the usual methods, using wire brush, etc., and was again cleaned in the field before the second coat was applied. For similar work of this nature, it is thought advisable to have the first cleaning of the steel in the shop done by means of a sand-blast before the first coat of paint is applied.

Report on Power Development, Power Transmission Tunnel[1]

By

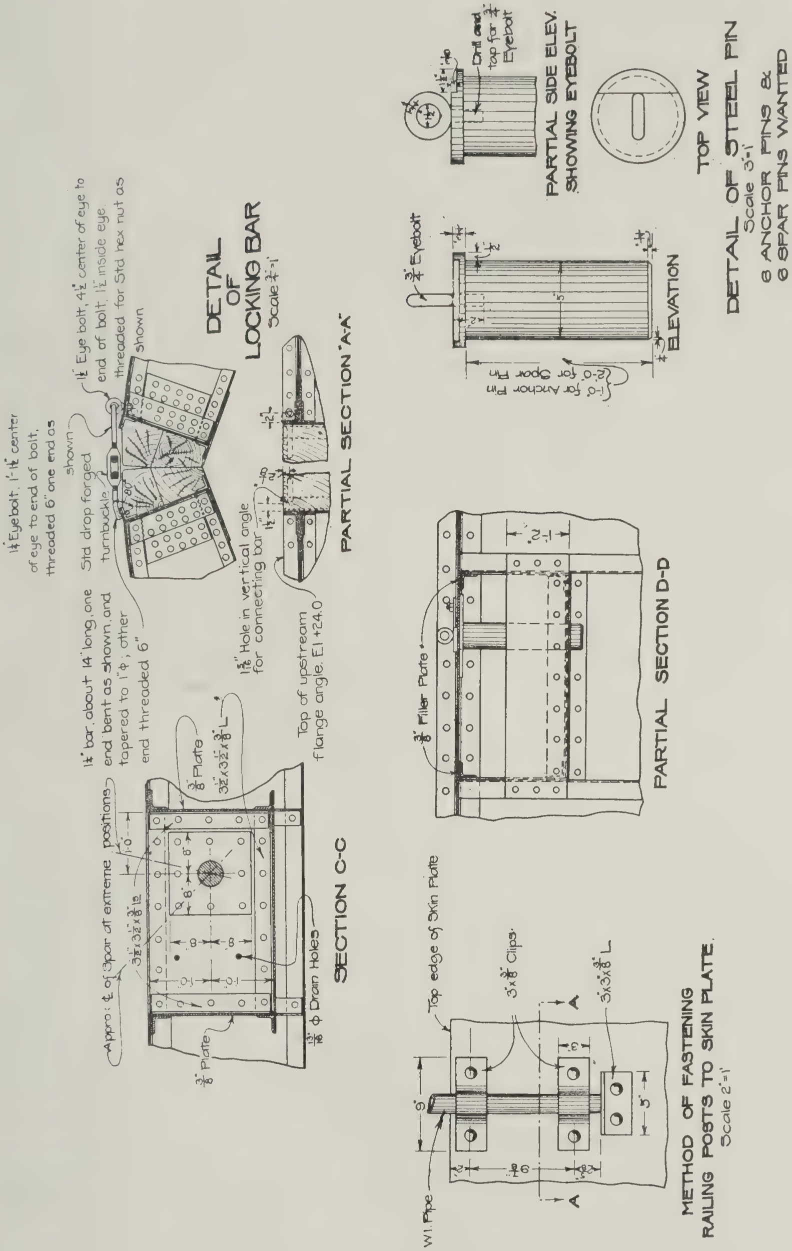
Mr. Frank P. Fifer,

Junior Engineer.

With a view toward future power development on the west bank of the Hudson River for commercial purposes, a power bulkhead was provided when the dam was constructed. Electrical current generated at that point can be transmitted across the river to Troy through a transmission tunnel which extends the full length of the dam. At the river wall of the lock, the tunnel dips down and passes beneath the floor of the lock, terminating in a shaft in the land wall.

The transmission tunnel in the dam is 2 feet 6 inches wide; and about 6 feet from floor to the highest point of the roof, which is a circular arch. The floor of the tunnel slopes transversely 1 inch in 2 feet to a longitudinal drainage gutter situated at one side of the tunnel. The floor of this gutter, which is 6 inches wide, slopes longitudinally 1 inch in 5 feet from an elevation 2 inches below the tunnel floor to a point 6 inches below. The alternate peaks and depressions of the gutter occur every 40 feet. At each depression a 2½-inch drain pipe extends from the gutter to the downstream face of the dam, on a slope of about 1 inch in 1½

[1]Revised by Maj. M. J. McDonough, Corps of Engineers, U. S. A.; and Mr. D. A. Watt, Assistant Engineer.



DETAIL OF LOCKING BAR
Scale 3/4"=1'
PARTIAL SECTION 'A-A'
SECTION C-C
PARTIAL SECTION D-D
DETAIL OF STEEL PIN
Scale 3"=1'
8 ANCHOR PINS &
8 SPAR PINS WANTED
PARTIAL SIDE ELEV. SHOWING EYEBOLT
TOP VIEW
ELEVATION
METHOD OF FASTENING RAILING POSTS TO SKIN PLATE
Scale 2"=1'

Fig. 7.

feet. Brass check valves are attached to the tunnel end of each drain pipe so as to prevent the flooding of the tunnel in case the water on the downstream side of the dam should rise above the elevation of the floor. This arrangement of drainage underwent successfully a test lasting nearly two months, during which the downstream water level stood at or above the crest of the dam.

The extension of this tunnel under the lock floor is 5 feet high and 2 feet 6 inches wide, being rectangular in section. Access is had to it by shafts in each wall of the lock, the shaft in the river wall having the tunnel through the dam opening into it. The walls of the tunnel in and under the lock were waterproofed, and a sump is provided at the bottom of the land wall shaft so that the tunnel and shafts may be unwatered should occasion arise. The waterproofing used was paraffin dissolved in gasoline applied hot and allowed to dry, after which the paraffin was driven into the concrete with a blow-torch. The tunnel through the dam was not waterproofed, the drainage pipes easily carrying away any seepage through wall or joints.

Report on Line Hooks, Ladders and Rubbing Strips[1]

By

Mr. Willson Y. Stamper,

Minor Draftsman.

Line Hooks. In each wall of the lock at 50-foot intervals, are line hooks to aid in snubbing or steadying vessels during the operations of filling and emptying the lock. The height of the bottom of the line hook recess above the water level of the lower pool is 12 feet. Line hooks are also placed at similar intervals in the lower guide wall of the lock at an elevation of 9 feet above pool level.

The line hook and recess were designed with a view to making the catching of the hook as simple as possible. In this type of hook and recess, the curved surface of the hook, the converging sides of the recess, and the guide plate back of the hook, all help to guide the loop of rope over the line hook. With this design, if the hook

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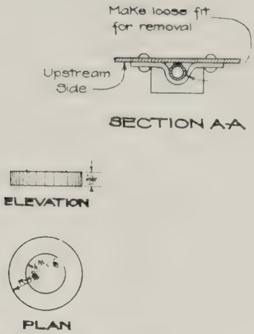
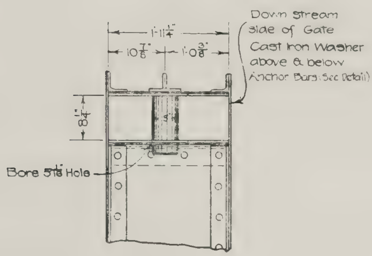


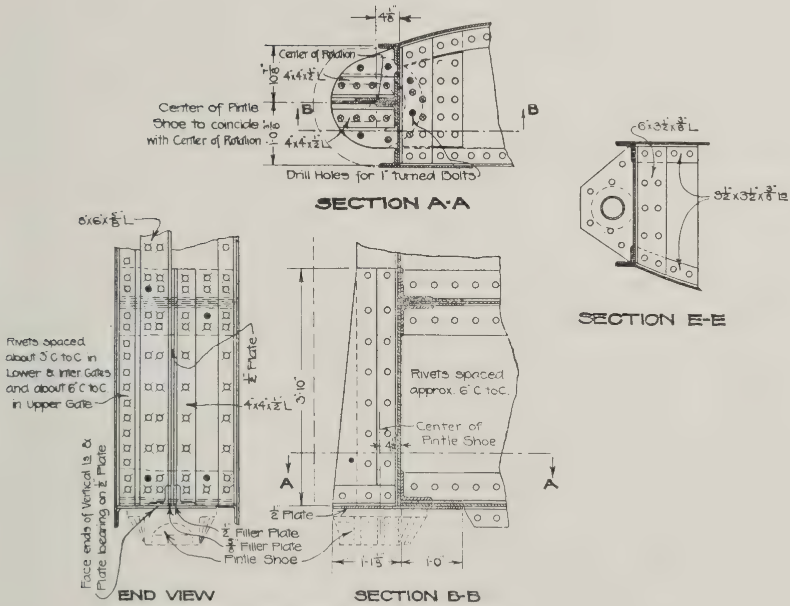
DETAIL OF CAST IRON WASHER FOR ANCHOR PINS

12 WANTED

Scale 1½"=1'



END VIEW
SHOWING ANCHOR PIN



DETAIL OF PINTLE BRACKET

Scale 1"=1'

Fig. 8.

hits any part of the recess it is almost certain to go over the hook. The details of this line hook are shown in Fig. 14. The hook and its base plate are of cast steel.

Ladder. At convenient locations in the lock and guide walls are situated ladders placed in recesses and extending from the lower pool level to the top of the walls. These ladders have sides of steel angles with 1-inch iron rounds. The depth of recess is 10 inches except at the top where the hand-hold deepens the recess 12 inches more. This large recess is designed to give the best possible means of access to the ladder. To descend, one first

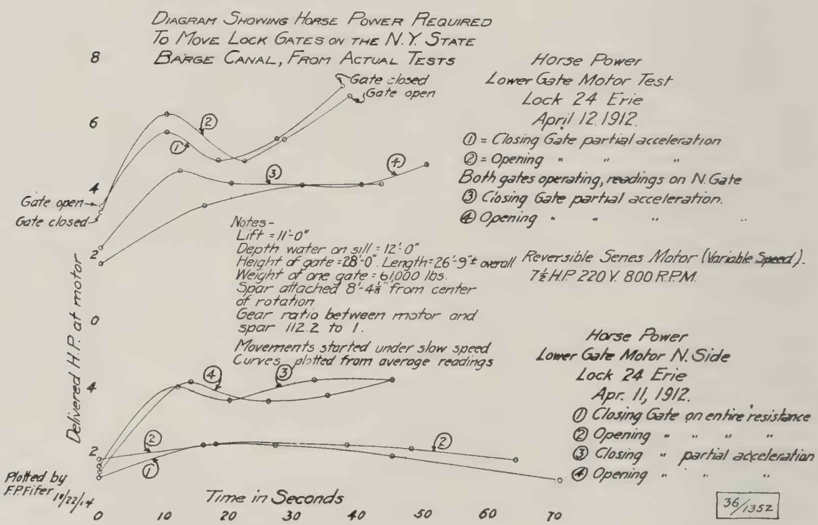


Fig. 9.

steps into the recess between the hand bars, stoops down to grip the bars and then steps onto the top round of the ladder without danger of losing balance. The continuity of the top of the wall, however, is preserved by means of a hinged cover of wood which is flush with the top of the wall. The use of this cover prevents accidents to anyone who otherwise might trip over one of the recesses. Where anyone is descending or ascending the ladder this cover is thrown back upon the lock wall. The ladder and recess are shown in Fig. 14. No part of the ladder or hand-rail projects beyond the face or top of the wall; hence, there is no interference with boat lines dragged along the cast-iron nosing.

Friction Fenders. In order to prevent damage to the lock walls by vessels, cast-iron friction fenders are placed every 10 feet along each wall of the lock chamber. These fenders extend from a point about 7 feet below the level of the lower pool to

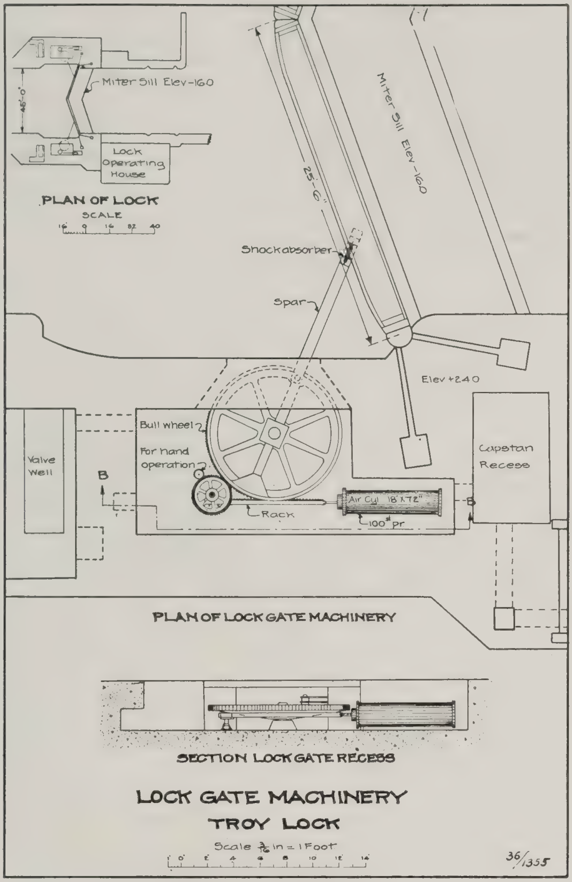


Fig. 10.

within 1 foot of the top of the wall, a height of 30 feet. The fenders are cast in 5-foot lengths, and are bolted to the lock wall by Richmond screw anchor bolts, spaced 1 foot 4 inches on centers. An elevation and section of the fender casting in place is shown in Fig. 14.

Description of Emergency Dam, Troy Lock and Dam[1]

By

Mr. Frank P. Fifer,

Junior Engineer

The preliminary plans for the lock at Troy included the use of two emergency dams or coffers, one at each end of the lock.

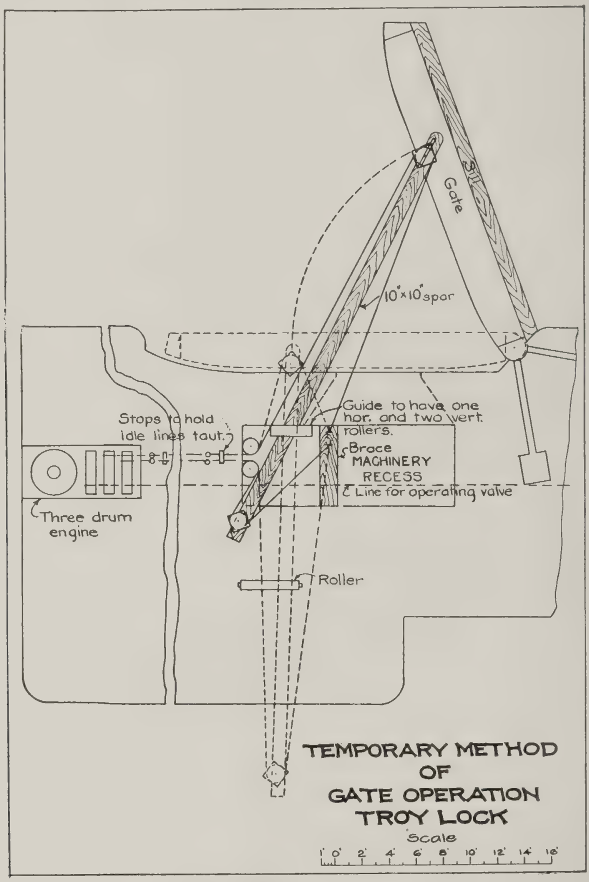


Fig. 11.

for use in closing off the dam in case of accidents or for the making of repairs. The single leaf or shutter type was investigated; the type that is hinged at the bottom and raised to vertical position by

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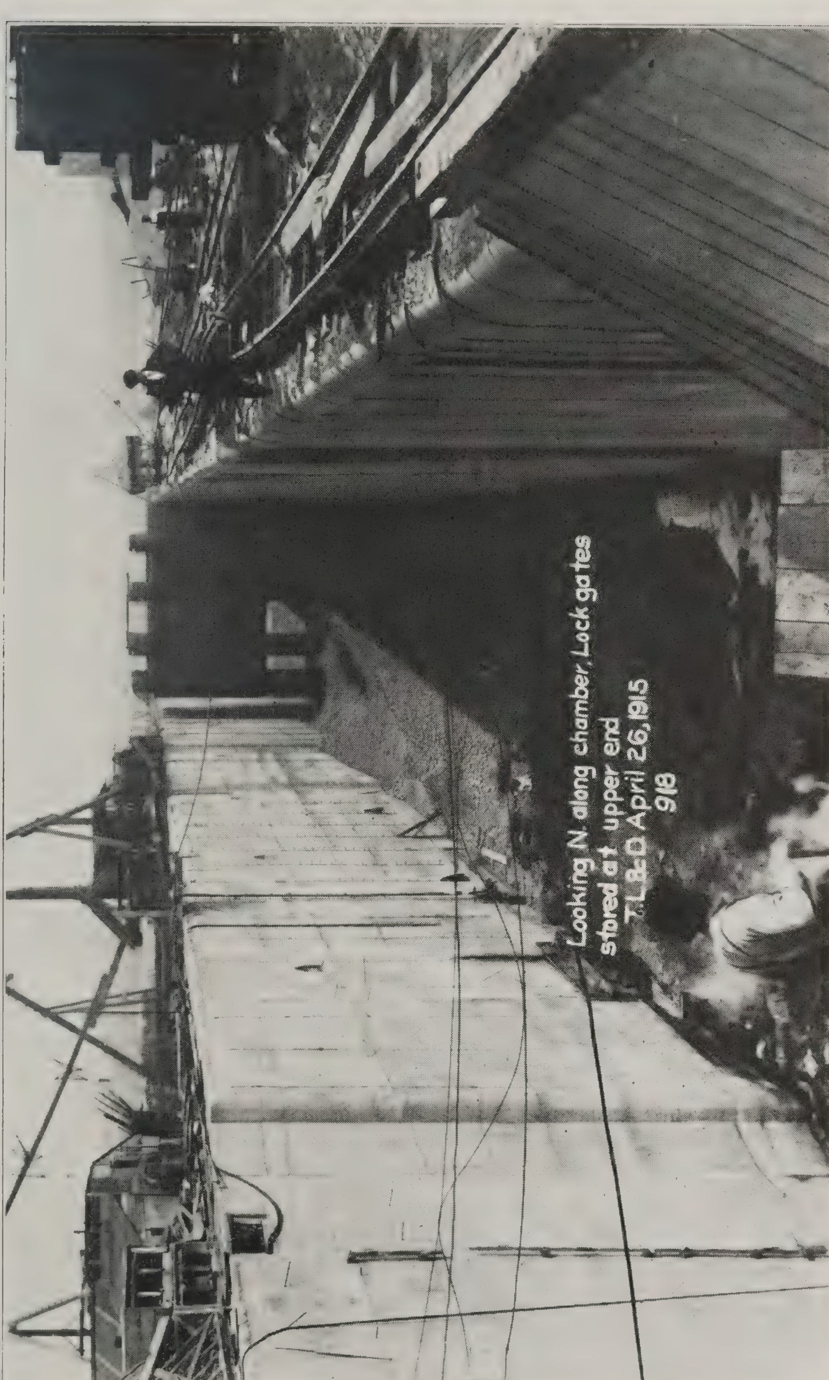
Looking N. along chamber, Lock gates
stored at upper end
T.L.&D. April 26, 1915
918

Fig. 12.

suitable mechanism. Various other means of raising the single-leaf type of dam were studied; no satisfactory solution of the problem of raising the single-leaf dam was found, and that type of dam was therefore abandoned.

The next step had for its object to dispense with the special type of emergency dam at one of the two ends of the lock chamber. If the emergency dam could be raised at either end of the chamber, quiet water would be assured in the chamber and thereafter the problem of coffering the other end or chamber would be simplified. The Boule type of dam was investigated. The total height of the Boule dam needed for the closure of the upstream end of the chamber would be considerably less than the same for the downstream opening of the chamber. It was, therefore, determined to use the Boule dam as an emergency coffering for the upstream end of the chamber. This dam was to consist of five trestles or bents hinged at the base. When out of use the trestles rested folded one upon the other upon the lock floor. The bents were to be raised to a vertical position by chains permanently connecting one bent with the other. The flow of water was to be checked by means of 15 or 18 inch steel channels lowered horizontally against the upstream face of the trestles. Upon further study the total number of bents, as well as the total number of steel channels, seemed to be excessive. The design was modified, therefore, so as to use three trestles spaced about 11 feet on centers instead of 5 feet; the steel channels were replaced by rolling gates or shutters of much larger size. This design of trestle bent as finally adopted is shown in Fig. 15.

With the design of the emergency dam completed, the closing of the other end of the lock became simplified. It was decided to make provision for a temporary dam that could be erected in quiet water after the upper emergency dam or lock gates were closed. A sill was, therefore, built across the lock chamber approximately 65 feet downstream from the lower miter gates. A vertical recess was placed in each face of the lock wall in the same vertical plane with the horizontal sill extending the full height of the lock walls. The two vertical recesses are 1 foot 4 inches wide and 1 foot 4 inches deep. The recesses serve as end seats for horizontal wooden coffering beams. Fifteen feet behind or upstream of the above-mentioned recesses are other recesses, one on each lock wall, running the full height of the lock wall. These recesses are mitered in the wall in such wise as to act as a seat

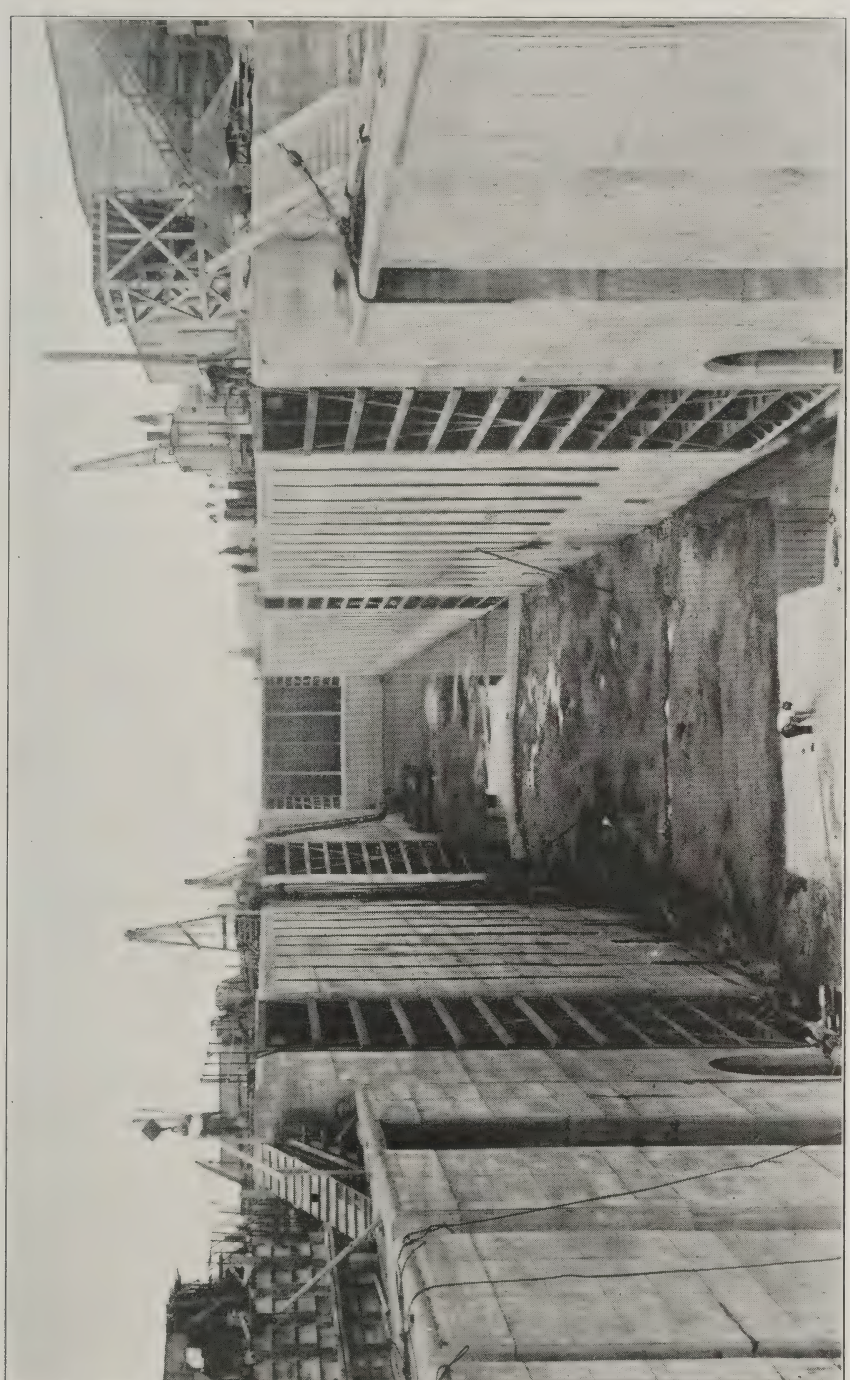

Fig. 13.

at any height of the wall for inclined braces, serving as knee supports to the horizontal coffering timbers above mentioned.

The emergency dam sill is located about 80 feet upstream from the upper miter sill and is at the same level as the latter. The top of this sill is 5 feet above the lock floor at this point and serves as a resting place for the lower tier of emergency dam gates when the dam is in place and as a protection to the trestles when they are resting on the lock floor (see Fig. 16).

Anchorages. The anchorages for the emergency dam trestles consist of cast iron shoes, each provided with two large anchor bolts. These shoes carry the steel pins upon which the trestles turn. Details of the anchorages are shown in Fig. 15.

The upstream shoe of each trestle consists of two parts placed one on each side of the base of the vertical trestle member. The eye of a $2\frac{3}{4}$-inch square loop-welded bar is placed over the $4\frac{3}{8}$-inch diameter steel pin, on each side of the member between it and the anchorage casting. The shanks of the eyebars (for purposes of adjustment and of renewal) are attached by sleeve-nuts to rods of the same size 9 feet long, the whole being grouted into the rock, the sleeve-nuts being surrounded with sand to permit of accessibility. A concrete buttress reinforced with deformed bars serves as a seat or support for the downstream half of the anchorage and serves as additional security against lateral thrust.

The downstream anchorage is a ribbed casting in one piece which carries a $5\frac{3}{8}$-inch diameter steel pin. The center lines of the inclined back members of the trestle and of the lower strut meet the center line of the pin at a point 15/16 inch away from the upstream face of the anchorage casting. These two members are riveted to a bearing plate 15/16 inch thick with butts against the casting, the pin going through the plate and casting.

The resultant thrust against the anchorage is provided for by two 3-inch diameter rods, 30 feet long, embedded in the floor. These rods extend from the base of the casting on a downward slope of 10 to $1\frac{1}{2}$ and end in an anchorage of steel plates and channels 7 feet long, which is embedded in the base of the emergency dam sill.

Trestle Bents. The trestle bents, three in number, are spaced 11 feet 3 inches apart over the chamber width of 45 feet. This divides the section into four equal parts.

Each trestle consists of a riveted truss, of built-up members and standard shapes designed to withstand a hydrostatic head

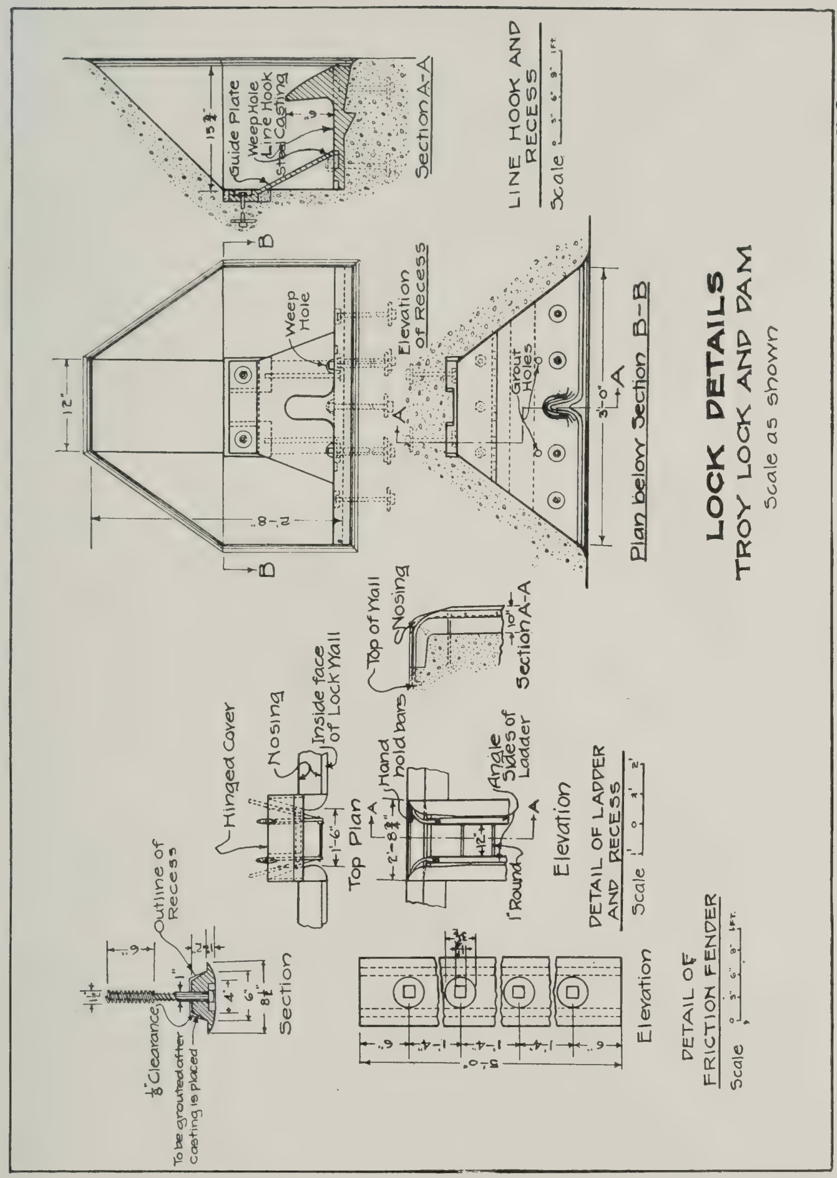
LOCK DETAILS
TROY LOCK AND DAM
Scale as shown
LINE HOOK AND RECESS
Section A-A
Guide Plate
Weep Hole
Line Hook
Steel Casting
Elevation of Recess
Weep Hole
Plan below Section B-B
Grout Holes
DETAIL OF LADDER AND RECESS
Top Plan
Hinged Cover
Nosing
Inside face of Lock Wall
Top of Wall
Hand hold bars
Angle Sides of Ladder
1" Round
Elevation
DETAIL OF FRICTION FENDER
Outline of Recess
1/8" Clearance
To be grouted after casting is placed
Section
Elevation

Fig. 14.

of 26 feet and a velocity head of 11 feet per second. The upstream vertical members serve as treads for the wheels of the emergency dam gates, countersunk rivets being used to give a smooth surface. The trestle bent next to the river wall has a cast iron bevel tread, as the gates at this point slant slightly upstream instead of at right angles to the lock walls. This construction was made necessary on account of the recess in the river wall into which the

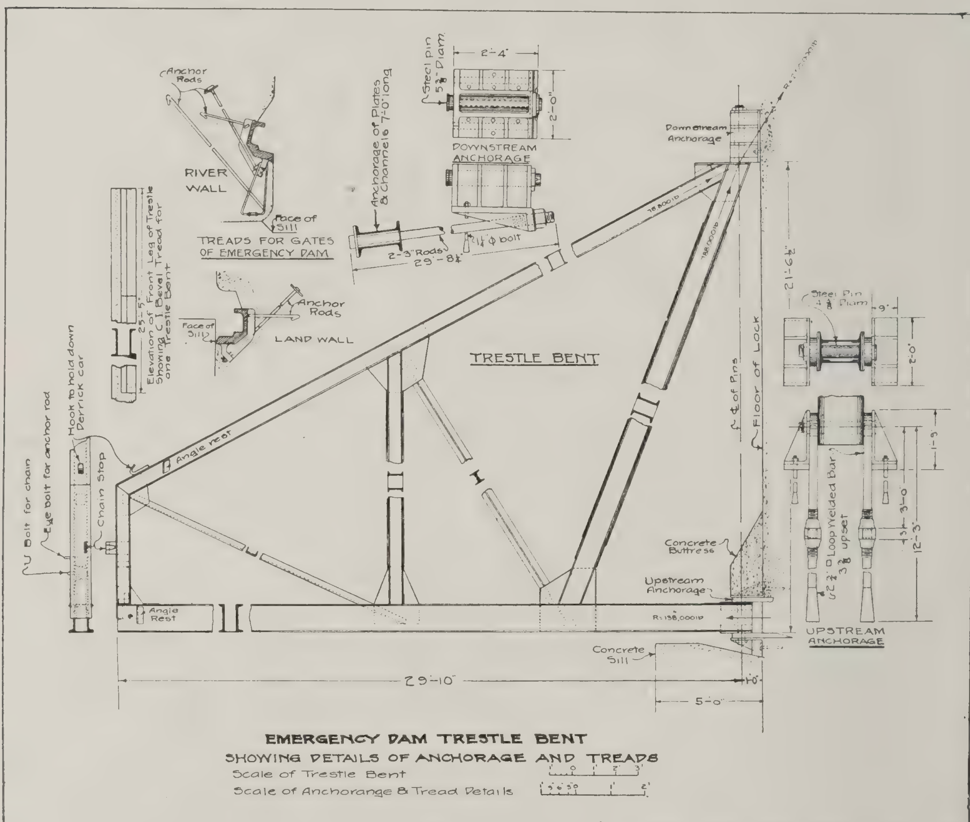

Fig. 15.

trestles revolve when not in use, as shown in Fig. 16. The considerable height and wide spacing of the trestles made necessary special provision for the thrust on the shoes. The most satisfactory solution was found to require the abandonment of the customary design of leading it to the upstream shoe, and, accordingly, the lower part of the upstream leg acts as a canti-

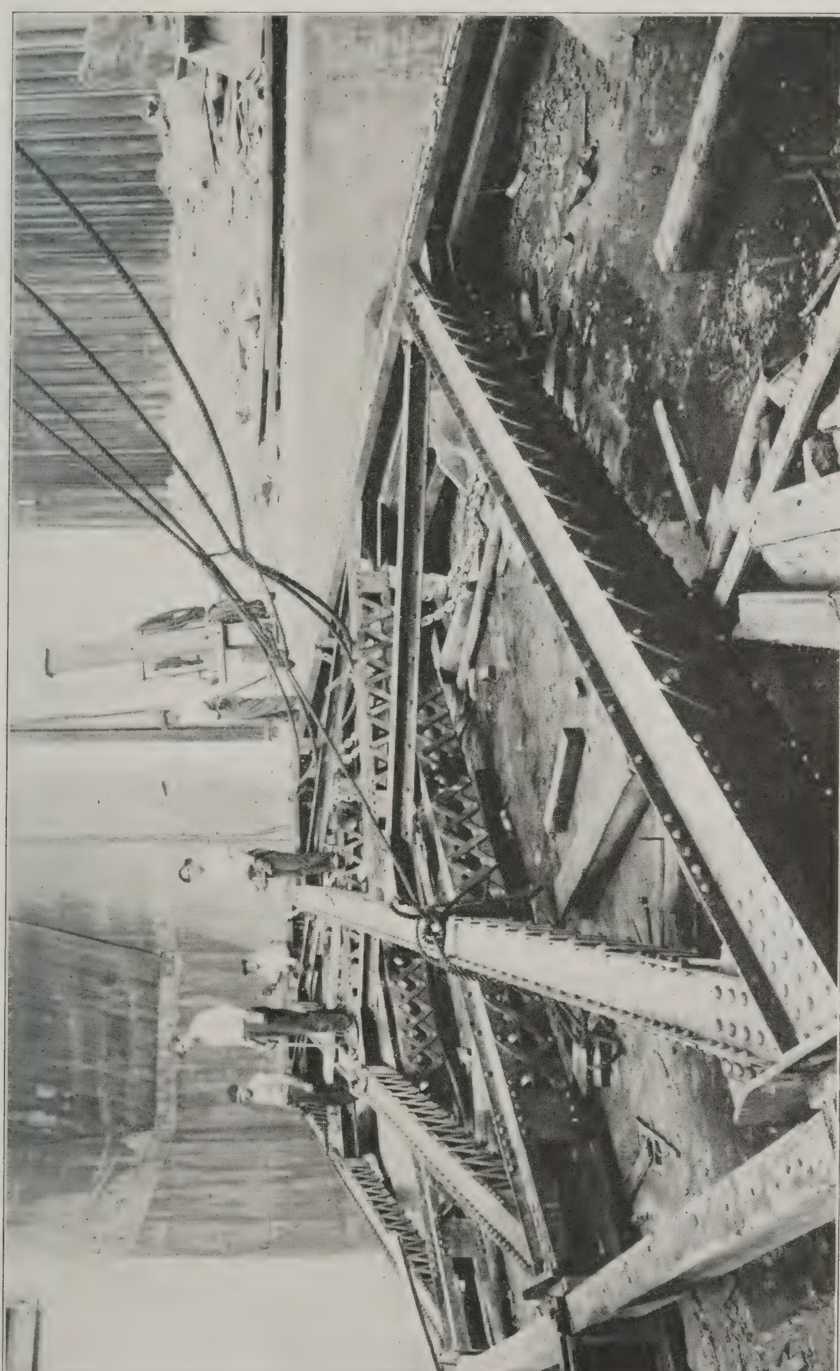

Fig. 16.

lever and all the thrust is carried to the large shoe downstream. Only by this means was it found practicable to transfer to the rock foundation, in a simple manner, the large water load. The upstream anchorage thus takes only the vertical component of the forces.

Gates. Each emergency dam gate consists of a framework of structural channels to which a curtain of buckle plates is riveted. The gates are of sufficient length to close the interval between bents, and are of the general type shown in Fig. 17. The gates nearest the walls are modified slightly as to length, as the

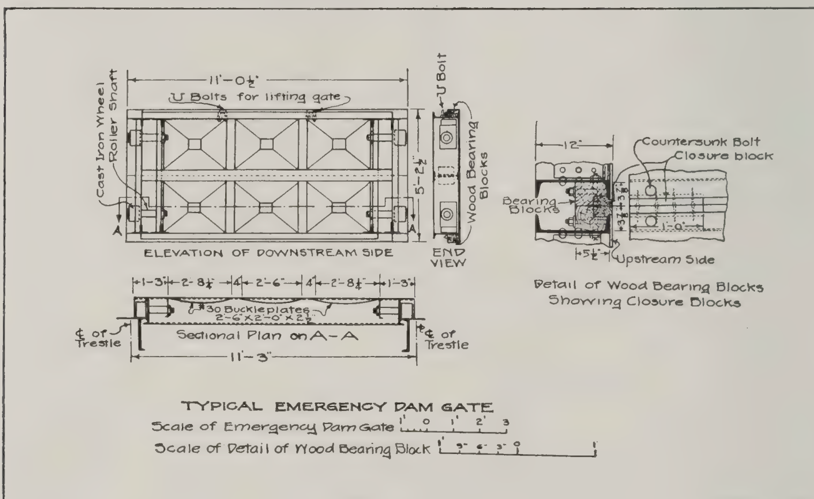

Fig. 17.

wheels on one side run on treads recessed in the lock walls, details of which are shown in Fig. 15.

Four sets of five gates each are used, the upper tier being practically on a level with the top of the lock walls. All gates are of the same height. Closure between tiers of gates is made by wooden bearing blocks extending the full length of each gate. The small vertical aperture remaining between the tiers is closed by planks, and sawdust or stable refuse may be scattered on the upstream side of the dam, which will effectively close any small cracks remaining. Two views of these gates are shown in Figs. 18 and 19.

Service Bridge and Track. When the trestle bents are in a vertical position, a service bridge and track rests upon the top of

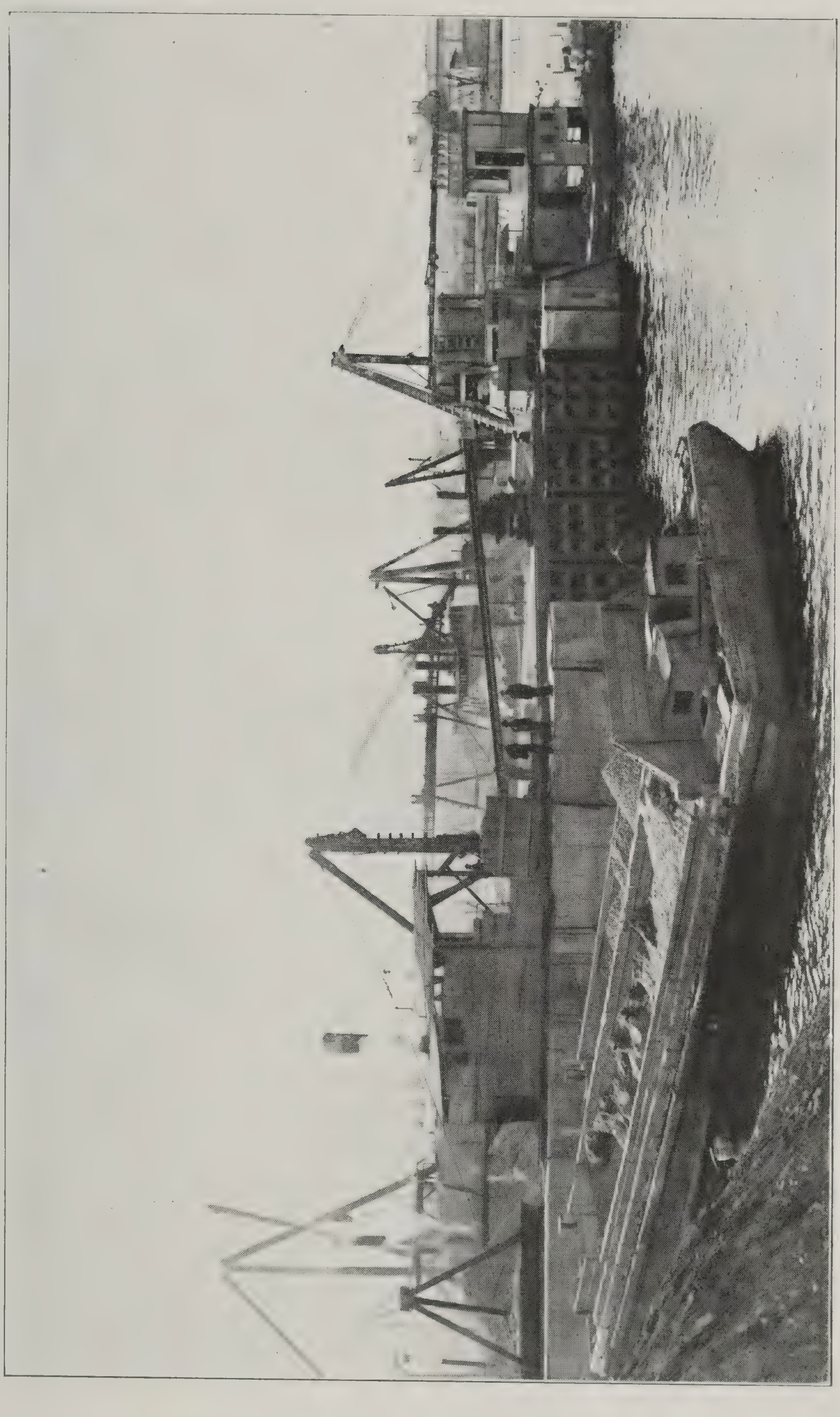

Fig. 18.

the bents and extends from wall to wall. It consists of two channel stringers, the top flanges of which serve as a track for a derrick car which is to raise and lower the gates. The stringers are in sections of sufficient length to span the interval between bents and are bolted to the top trestle members, thus holding them together. Lateral swaying motion of the stringers is prevented by steel straps.

Planks are placed at right angles to the stringers, the ends resting on shelf angles riveted to the web of the channel stringers. The planks are secured against slipping by pins in the planks engaging with holes in the shelf angles. The planks shown in Fig. 20, are of a temporary character. A removable section of track rests on the land wall and connects with a track leading to the housing for the derrick car.

Method of Operating the Dam. The successive steps in raising the trestles are shown in sectional elevation (Erecting Trestles) in Fig. 21. The trestles when not in use rest upon the lock chamber floor behind a sill and extend into a recess in the river wall. The trestle bents are raised to a vertical position by means of chains connected (temporarily) to a hoisting engine in the adjacent storehouse. The engine is operated by compressed air from the lock powerhouse. Each chain is of sufficient length to reach from a bent when lying on the lock floor to the top of an adjacent bent in raised position. When the emergency dam is not in use, the chain attached to the bent next to the land wall lies on the lock floor behind the sill and in through the tread recess for the gate wheels, and is fastened in this recess within reach from the top of the wall.

Referring to Fig. 21, the first trestle is raised to a vertical position by the hoisting engine on the land wall as shown in sectional elevation (Erecting Trestles). The sections of track and bridge leading from the land wall to the trestle are then put in place by hand and bolted down. The end of the chain leading to the next trestle is then removed from its stop and attached to the line from the hoisting engine. After the roller is placed on the first trestle as shown the second bent is raised and the next section of track is placed by the same method as the first. The last trestle is then raised, a guard chain fastened to the river wall preventing it from falling toward the land wall. The three trestles in position with the track nearly across is shown in Fig. 22.

The track and service bridge being in position, the gates are lowered by means of a portable gin pole up on the trestles as shown

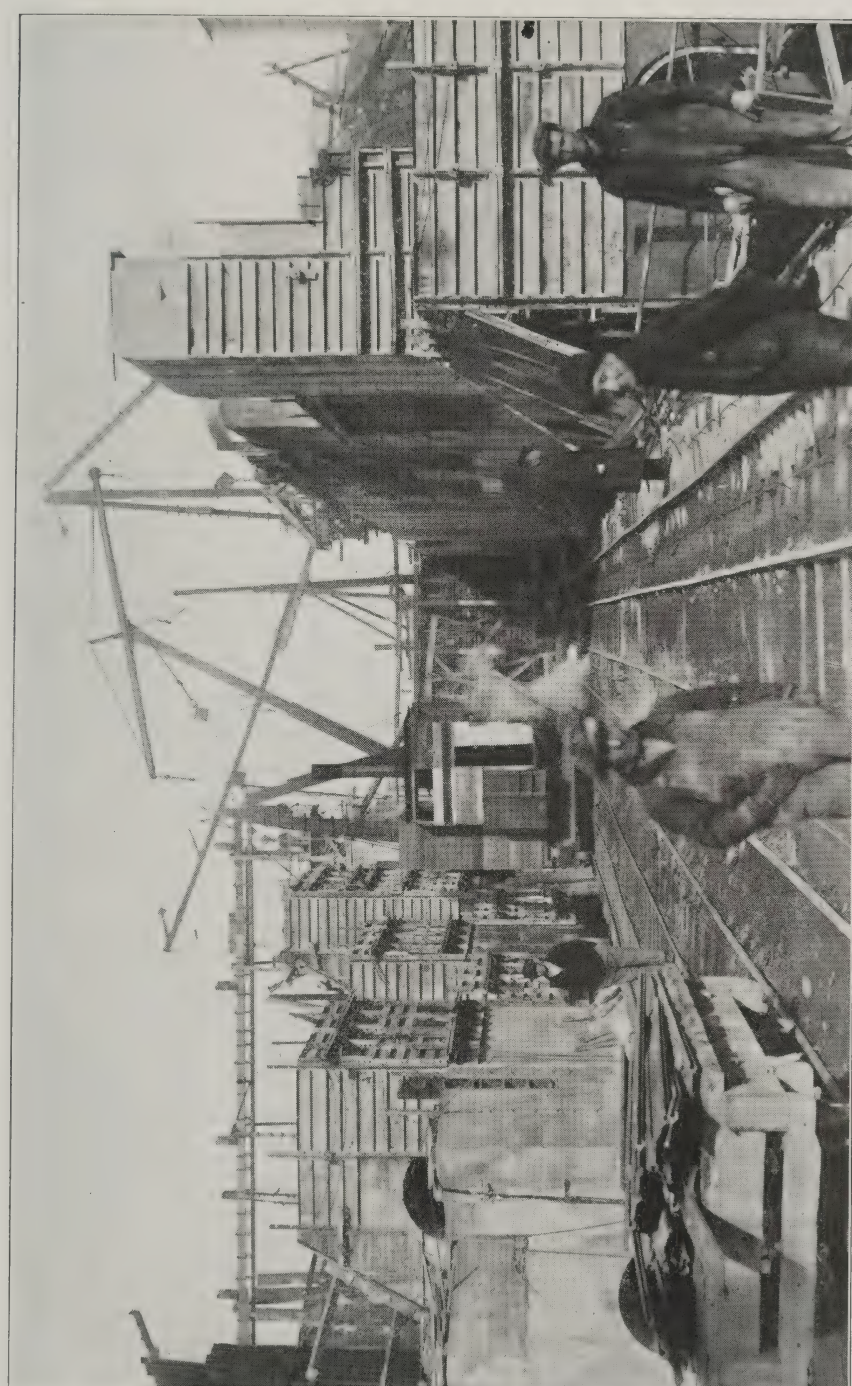

Fig. 19.

in plan and sectional elevation (Erecting Gates) in Fig. 21. A bridle chain is secured to the top of each gate by "U" bolts, and a hoisting chain attached to the bridle extends to the service bridge. This chain is made long enough to allow for the sweep of the current and terminates in a ring. When the gates are in place, the rings are dropped over hooks riveted to the upstream stringer of the service bridge. These hooks and rings are shown in Fig. 20. By this means, the chains are easily reached when the gates are to be raised.

When the dam is to be removed, the operations described are performed in the reverse order.

The two drum hoisting engine for raising the trestles, operating the gin pole, and hauling the service car back and forth, will be permanently located in the storage house for the Emergency Dam equipment. This storehouse has been located at a point convenient for the operation of the lines. The lines will be lead through snatch blocks and over rollers as shown in Fig. 21.

From a trial made with the operation of the dam with the equipment and methods as described above, it was shown that no difficulties would be encountered and it is estimated that the entire dam could be erected by an experienced crew in about ten hours or less.

It is believed that operation by the equipment as described above is preferable to that by a traveling derrick car, which was the method first contemplated, as it would have been difficult to place on a small car the necessary machinery and to have adapted the body for a derrick also. In addition, the machinery on the derrick car would have needed to be built for this specific purpose, whereas the hoisting engine referred to above was on hand.

Report on Laying Concrete in Freezing Weather[1]

By

Mr. D. A. Watt,

Assistant Engineer.

In order to have the Troy Lock completed and ready for navigation within the specified time, it was found necessary to carry on the work of placing concrete in the lock during the winter 1914-15. Various expedients were used to prevent damage to the concrete from frost.

[1]Revised by Maj. M. J. McDonough, Corps of Engineers, U. S. A.

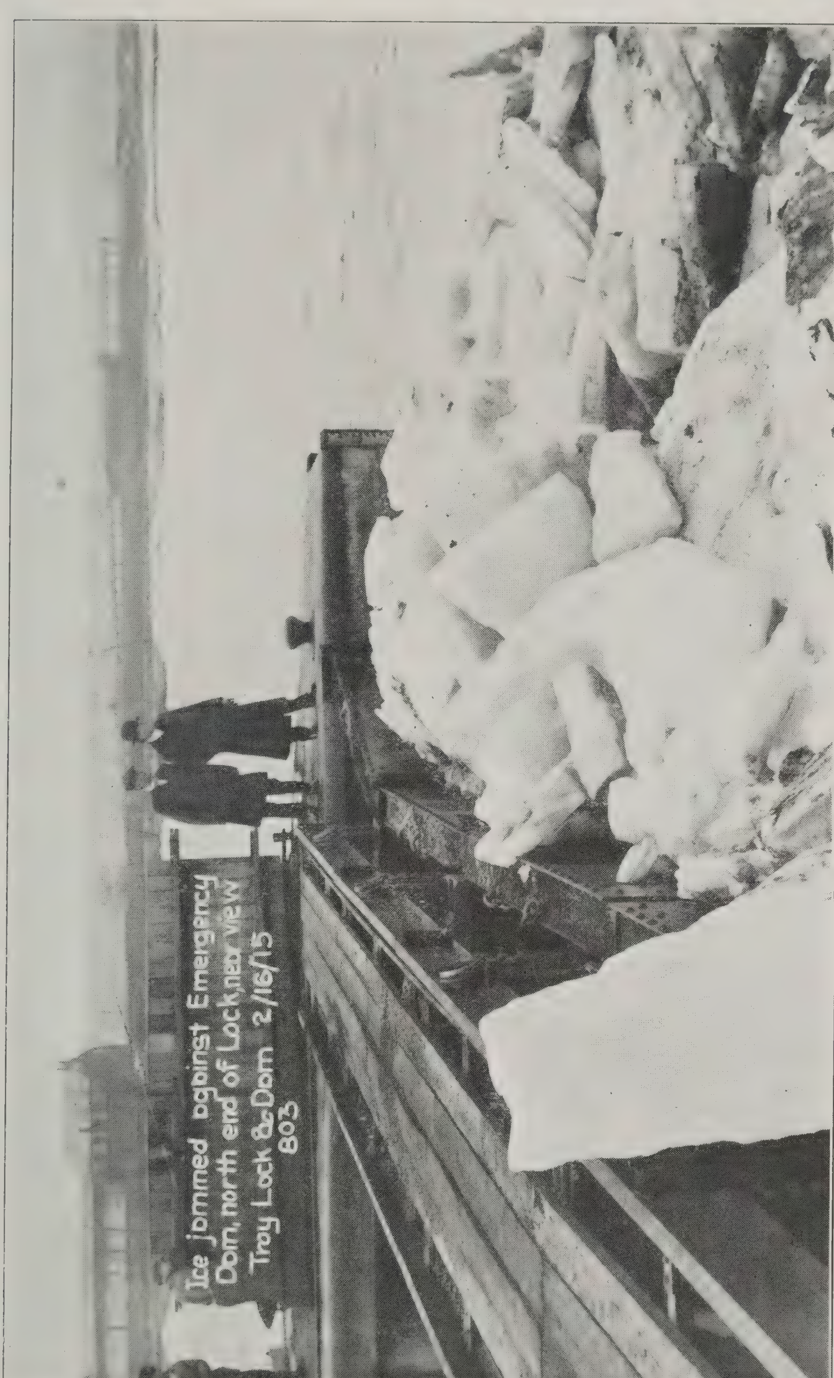
Ice jammed against Emergency
Dam, north end of Lock, near view
Troy Lock & Dam 2/16/15
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Fig. 20.

When the temperature fell below about 50° F., the sand, gravel and water used in the concrete were heated. A steam jet placed in the water tank of the concrete mixer sufficed to heat the water.

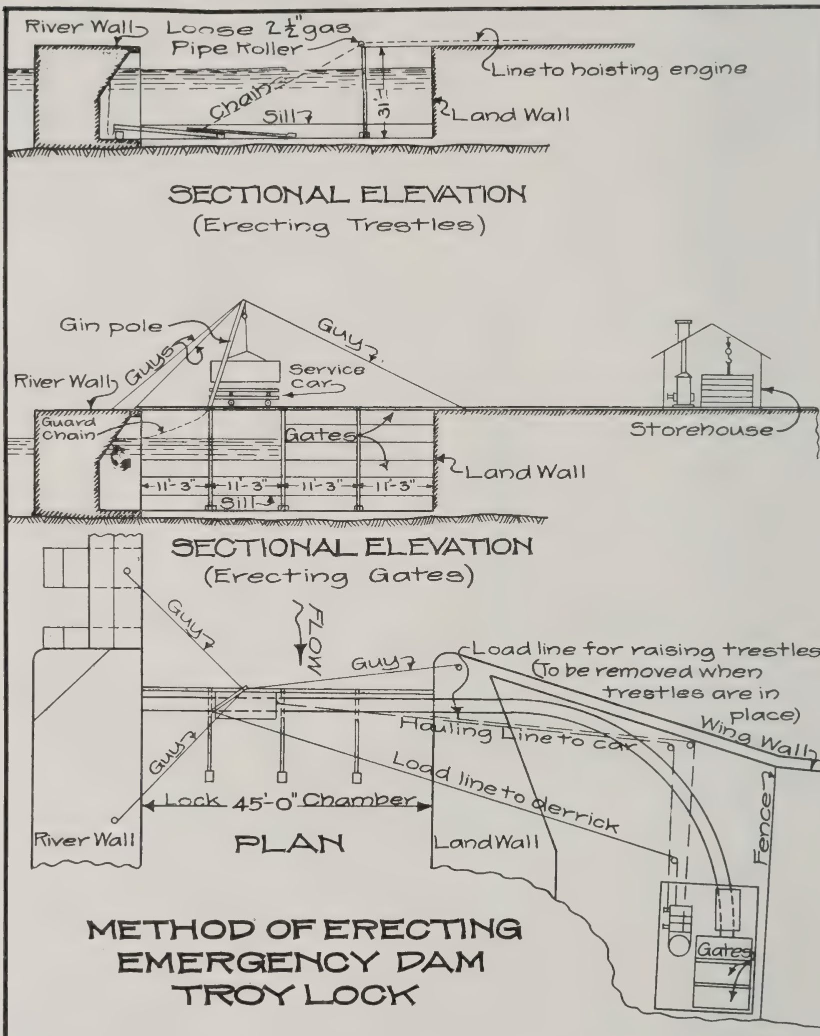


Fig. 21.

The sand and gravel were heated by steam jets located at the bottom of the bins of the mixer. The steam, escaping upward through the mass, made this method very effective, even when the mixer was running to full capacity. When running slowly, however,

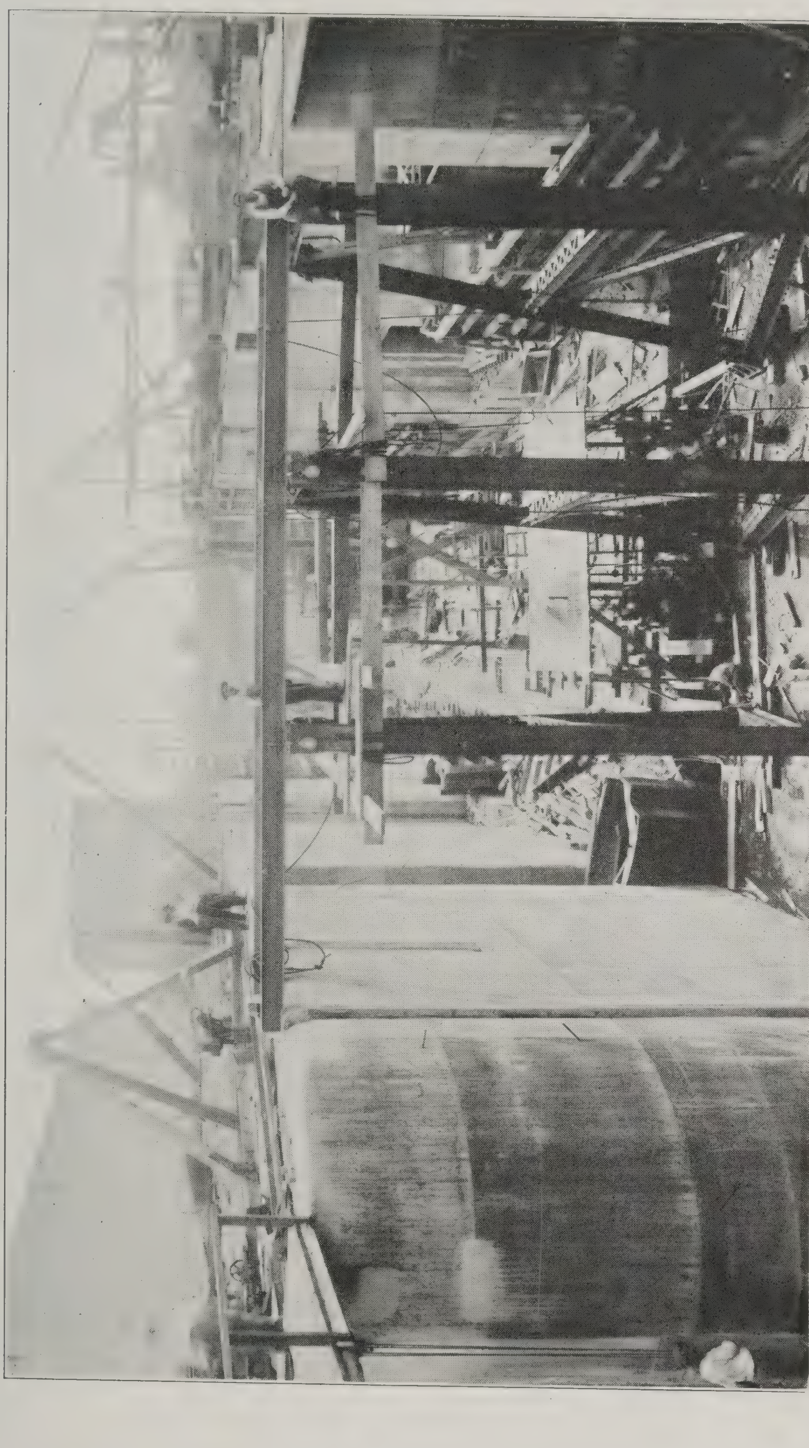


Fig. 22.

it was sometimes necessary to reduce the supply of steam, as it made the concrete too hot for the men to work in the forms, and in confined forms resulted in so much vapor that the men could not see properly.

This method was also used on the construction of the dam, when toward the end of the working season the temperature fell below moderate. As the river water was shortly to be allowed to flow over the new section of the dam, it was necessary to harden the concrete rapidly, and this method proved very effective.

When the temperature fell below freezing, additional precautions were taken. Lighted lanterns were placed on top of the green monolith; and large improvised steam radiators, made of a few coils of 3-inch pipe, were hung close along the side of the forming; the whole was then covered with a paulin, and so left for about 48 hours. Loss of heat by radiation from steel forms is much greater than from wooden forms.

Concreting was carried on without special difficulty under occasional temperatures not far from zero, and the temperature of the concrete when delivered in the forms were rarely less than 60° F. The steam coils and tarpaulins were usually kept in place for about 48 hours, when the concrete had set sufficiently to allow the forms to be taken down. The lifts or thickness of courses ran from 3 or 4 to about 10 feet.

Difficulties also arose from the surface freezing of the sand and gravel storage piles, on which the cold would sometimes produce a frozen crust of a foot or more, hampering the operation of the excavating bucket. This was overcome by using steam pokers, consisting of 1¼-inch steam pipe about 10 feet long pointed at one end and having a few small holes. Two or three of these would be worked into the storage pile over night near its base, its surface being covered with tarpaulins. The expenditure of a very small amount of steam would heat by morning all the material within several feet of the pokers, and melt all the adjacent frozen crust.

Comments on Construction of Lock and Dam at Troy, New York.[1]

By

Maj. Gen. W. M. Black,

Chief of Engineers.

It is rare that any extensive work of engineering construction does not afford opportunity for the exercise of originality either in adapting conventional methods to the local conditions or in actually improving on common practice. The Troy lock and dam was no exception to this rule and departures from ordinary practice were made in all stages of its construction. Some were necessitated to meet conditions while others were deemed improvements. Detailed descriptions of some of these have already appeared in the MEMOIRS. It may not be inappropriate to recapitulate these briefly.

Upon tearing out the old crib dam built in 1823, tests were made of the spruce timbers therein which had been submerged nearly a century. Under test they developed a tensile strength of from 7,000 pounds to 12,000 pounds per square inch. This compares very favorably with a normal tensile strength of 10,000 pounds per square inch as noted in Trautwine.

One style of cofferdam used consisted of a row of flattened cylindrical chambers, or shells of steel piling, the cylinders being placed side by side with the piles of one locking into those adjacent. The cylinders were driven in water from 12 to 24 feet deep and the largest one was about 40 feet across and 40 feet in height. They were filled with sand and gravel dredged from the river, this material being used to provide stability and water tightness. Although high in first cost, the same piles were used for other cofferdams thereby greatly reducing the cost, especially as the piles were sold for a considerable sum on completion of the construction. The sand and gravel filling of one cofferdam was used to a great extent for the next cofferdam, much of the surplus being used in making concrete. This style of cofferdam was quite similar to the cofferdam of the Black Rock lock at Buffalo, N. Y. In its use care must be taken to place the filling materials progressively in adjacent

[1]In No. 52, on Contents page (iii), for "Construction of Concrete Dam in Hudson River, at Troy, N. Y., 1916. By Mr. A. C. Harper, Assistant Engineer," read "Construction of Concrete Dam in Hudson River, at Troy, N. Y., 1916, in charge of Col. W. M. Black, Corps of Engineers. By Maj. M. J. McDonough, Corps of Engineers, and others."

cylinder pockets. If one cylinder be filled too much in advance of its adjacent cylinder distortion of the partition walls will result. Later it was found that the type could be modified and its cost reduced, by using cylinders of the kind used in the Maine cofferdam at Havana combined with straight lines of interlocking steel sheet piling. Instead of the cylinders being placed closely together as at Havana, they were spaced a considerable distance apart with a single line of interlocking steel sheet piling between them. This piling was reinforced by both an exterior and interior sand and gravel fill. The cylinders acted as anchors for the lines of piling at corners and along the sides. The piling prevented any cutting out of the earth fills by overflow as well as increasing the tightness of the dam. Sluice ways closed by sliding gates were placed in each cofferdam to admit of flooding the coffer when desirable without interior wash, as happens when the water is allowed to flood over the top of the dam.

For construction of the lock, two small derricks of special pattern were devised. They were made narrow so as to pass each other but had a long reach, so as to cover the wide foundations and the considerable height of walls. This reach was obtained by using an over-hanging arm built up of channel irons. The width of the derrick frame is 10 feet and its length 24 feet; the mast is 24 feet high, the boom is 40 feet and the outward over-hanging arm has a reach of 16 feet. Owing to the narrow base of the derrick, ample counter weights of sand and gravel had to be used, and in lifting weights on a low boom a portable guy was strung from the top of the mast.

The emergency dam to shut out the river in case of accidents happening or repairs becoming necessary was of rather unusual size, the depth from the top of the walls to the sill being 26 feet. This dam is of the Boulé gate type consisting of three large steel trestles which, when not in use, are turned down on hinges, the tops extending into recesses in walls. The trestles are spaced over 11 feet apart, and a series of steel gates, each about 5 feet high and with small wheels on the back, are placed in front of them and roll down or up as the dam is closed or opened, being handled by means of chains.

To prevent wall scarring by the boats, vertical strips or fenders of cast iron with rounded fronts projecting two inches from the concrete, were used with success. These strips were placed in short lengths and bolted to the walls, the bolt heads being countersunk.

The top edges of the lock faces of the walls were also provided with quarter round cast iron strips or nosings to prevent mooring lines from cutting into the concrete.

Between the vertical fenders there are occasional line hooks to be used by boats for mooring when locking through. These have proved very useful at the Troy lock, as the boatmen can attend to their own lines without the help of lock tenders. These hooks are so designed that they hold the bight of a rope against a downward or horizontal pull but instantly release it when the pull is upward. The hooks are in recess to engage rope easily.

Another convenience in the locks are ladders placed in recesses at intervals along the wall. The tops of the ladders are placed so that a man can pass easily and safely from the top of wall to the ladder, and the reverse, yet the top of wall presents a smooth, unbroken surface for the movement of the lock attendants and for handling lines. All the accessory iron work of the lock is so designed and set that the broken parts can be renewed without disturbing the concrete.

Mention might be made of the fact that the tops of the walls were brought to grade and surfaced with wooden floats giving a safe footing. The use of steel floats for surfacing concrete was forbidden since such floats bring an access of cement to the surface which, after a short time, develop a net of unsightly hair cracks.

The upper guide wall is used to protect boats from the effect of cross currents. As a cofferdam would have been very expensive for the 18-foot depth of water and the small amount of masonry involved, the wall was made in a series of isolated piers 10 feet wide with spaces of 10 feet between and with a continuous top above the water line. For laying the piers bottomless reinforced concrete cribs built in the dry were lowered in place after the river bed had been dredged and levelled with bags of concrete. Vertical reinforcing rods were placed through the interiors of these cribs which were then filled with concrete delivered through a tremie. This construction insured a hard and compact surface for the guide wall. The imperfections of the interior concrete fill, placed in the water are thus made of no moment.

The large wooden cofferdam, over a thousand feet in length, inclosing the west half of dam was an interesting problem. To avoid expense and risk it was necessary to finish the cofferdam and masonry in it during one working season. A special method known as the Ohio River type, permitted rapid building of the frame work.

To build this coffer there were first constructed two frames like trestle bents consisting of vertical posts with sway bracing, and iron bolted and strutted. Two of these frames were stood up on a barge, transverse to the length of the proposed coffer and parallel with about 20 feet between them and properly held in place by slings and guy ropes. To these frames were then bolted the horizontal stringers or waling pieces, at the different elevations on both sides. Vertical plank were also bolted at intermediate points on the stringers so as to give a stiffness to the entire frame but permitting a pivot or pantagraph motion about horizontal axes. The framework at this stage of construction looked like the posts and rails of two parallel board fences tied together. This frame was picked up by slings from the derrick boat which stood alongside the barge and the barge was then pulled ahead lowering one end of the frame into the water. One end of the frame still rested on the barge. Another frame was built, connected and launched as before, just as a line or universal joint pipe is assembled and lowered to the bottom of a stream, this movement being permitted by the pin or bolt connections between the sections of the crib. In measure as this framework was placed the sides were made tight with sheet piling driven on the inside and filled by a clam shell dredge.

The width of the Hudson River at the site of the Troy lock is 900 feet. The width taken up by the lock and by the power head gates is 225 feet. To reduce the flood heights above the dam, it was deemed desirable to give as long a crest to the dam as practicable. For this reason the plan shown on the map (MEMOIRS, No. 52, p. 439) was adopted. In order to reduce the effect of the cross currents formed by the flow across the diagonal arm of the dam, the crest of this arm was placed at an elevation 2 feet higher than the crest of the east arm. The length of the east arm is sufficient to provide for the low water flow of the river within this difference of level, so that the currents leave the dam approximately parallel to the channel of approach to the lock, and cause a minimum of disturbance to traffic in this approach channel.

The dam was of concrete built in 20-foot sections, keyed together by forming each end of each section into a waved surface instead of using the customary isolated tongues or keyways. A maximum interlock is thus obtained and the trouble of placing and moving separate keyway boxes is avoided; expense is saved as no time is lost in placing separate keys; nor is there any resulting

breakage loss in moving these key boxes. Alternate sections were first placed and then the filling sections. No effort was made to obtain a bond between the concrete of the various sections.

To provide a safe passage for the transfer of power from the power site on the west end of the dam to the east bank, a tunnel was formed in the body of the dam concrete. This tunnel was drained by means of vents leading to the downstream face of the dam.

In several cases springs were encountered under the site of the dam. These were rendered harmless by piping the water therefrom to the down-stream face of the dam.

To protect the concrete dam as well as the concrete walls of the lock against the effects of frost, the concrete was made dense and every effort was taken to protect the skin formed by the spading along the faces of the forms. Excepting where actual imperfections in the skin were found, no plastering was permitted.

To close the 125-foot gap left in the cofferdam to care for the flow of the Hudson River until everything was ready to make the final closure and turn the water over the portion of the dam finished the year before, a novel plan was used. A steel pile cylinder, 25 feet in diameter, was set in the middle of the 125-foot opening, lacing two openings of about 50 feet on each side. A line of piling was started from each side, these piling supported against a wire cable so they could be held against the current, a loop of the wire cable being used near the top and bottom to assist holding them in place.

The lock gates and culvert valves are operated by compressed air, the most suitable source of power for river locks as the machinery can be exposed to high water without damage and is more sturdy and less liable to get out of order than electrical machinery. The operation of the lock gates is made by a spar attached to the rim of a bull wheel which operates like the crank of a steam engine, similar to the lock gate machinery on the Panama Canal. Air is compressed by a water turbine attached to a compressor while a second air compressor operated by a gasoline engine provides for a breakdown of the turbine. The lock gates and valves can also be operated by hand if necessary.

It was on this construction work that one of the concrete foremen solved the puzzle of sand streaks in concrete. These streaks were more prevalent in the wetter concrete and more common where steel forms were used rather than the wooden forms. It had been thought that these streaks were due to the excess of water

in the concrete working its way to the face of the form and then percolating downward carrying the cement away from the face. This belief was not substantiated by an examination of the work at Troy as there was no deposit of cement at the lower end of the streaks, nor could any trace of collected cement be found anywhere along the streak. Again the streaks were wider at the top than at the bottom whereas it seemed that water percolating downward would tend to spread out. It was discovered that the water percolated upward, carrying the cement with it, not only at the face of the forms but at various points in the mass of the concrete. It appeared to be due to the weight of the concrete forcing out the excess water which followed the easiest path of escape, which was upwards, escaping through very small fissures or holes not larger than a pin-head. The flow would continue for a minute or two and when it stopped there would be left upon the surface a small flat cone of cement. This accounts for the fact that no cement appears at the bottom or along the sides of such streaks when the forms are removed as it is all carried upward to the surface.

The design and construction of the lock and dam were carried on under the direction of the writer, then in charge of the First New York District, River and Harbor Improvements. His principal assistants were Colonel (then Captain) R. D. Black; Colonel (then Major) M. J. McDonough; Assistant Engineers D. A. Watt and A. C. Harper; and Junior Engineers F. P. Fifer and J. J. McCabe. All took the greatest possible interest in the work and credit for original designs and for the sucessful completion of the work is due to all, as well as to the force under their charge.

THE BALKAN THEATRE OF WAR.[1]

From

"Topography and Strategy in the War," by Douglas Wilson Johnson, Henry Holt and Company, Publishers.

THE BALKAN BARRIER.

NEAR the head of the Adriatic there rise several small streams whose waters flow almost due eastward through the Save and Danube Rivers, to empty into the Black Sea. South of this west-to-east river trench, and separated by it from the open plains of Hungary and Rumania, lies the rudely triangular mass of complex mountainous country known as the Balkan Peninsula. The bulk of this difficult terrain long stood as an effective barrier between the Central Empires and their Turkish ally. The north-western corner of the triangle, comprising Bosnia and Herzegovina, was largely under Austrian control, while in the eastern corner the Turks were effectively resisting all attempts of the Allied armies and navies to dislodge them. But the rest of the territory was either openly hostile to the Teutonic powers, or was maintaining a wavering neutrality which constantly embarrassed communication with the Turks and threatened to become an active menace at any moment. It was to resolve this intolerable situation and to impress the world by a decisive military achievement that the German General Staff planned the Balkan campaign of 1915.

THE MORAVA-MARITZA TRENCH.

Through the mass of the Balkan Mountains rivers have cut two great trenches which constitute the only important lines of communication in the region. One of these passageways or ''corridors'' runs southeastward from Belgrade on the Danube to Constantinople on the Bosporus and consists in large part of the valleys of the Morava and Maritza Rivers. The other connects Belgrade with the harbor of Saloniki on the Aegean Sea and is formed by the Morava and Vardar valleys. From Belgrade as far as Nish the Morava valley is common to both routes. Although possession of the Morava-Vardar trench incidentally became essential to the Teutonic powers

[1]Reprinted through courtesy of Henry Holt and Company.

for military and political reasons discussed below, it was primarily for control of the Morava-Maritza depression that the campaign was undertaken.

The full significance of the Morava-Maritza trench can be appreciated only in case we recall the important rôle it has always played in the history of the Nearer East. From all parts of Europe highways of travel converge southeastward toward the points where Occident and Orient touch hands at the Bosporus. Whether coming from the plains of the Po over the Pear Tree pass, from western and central Europe along the upper Danube, or from farther north through the Moravian and other gaps to the Vienna gateway, travelers find the mass of the Balkans blocking the path to Constantinople and the East; just as in other days the hosts which invaded Europe from the lands of Asia Minor found in this same barrier an impediment to progress toward the northwest. Under these conditions it was inevitable that a continuous river trench cutting clear through the barrier from the plains of Hungary to the shores of the Bosporus should become a topographic feature of commanding historical importance.

Long before the time of the Romans the Morava-Maritza valley had become a highway for peoples migrating east or west through the mountainous Balkan lands. In a later day one of the principal Roman military roads led from Belgrade through the trench to Constantinople. The great Slavonic flood which issued from the plains of northeastern Europe through the Moravian and Vienna gateways entered the Morava valley and, in the seventh century of our era, was flowing through the trench to surge about the walls of Adrianople. A few centuries more, and the mountain sides were echoing the shouts of the Crusaders who toiled along the same pathway to fight for the Holy Sepulcher. Back through the same defile came those hordes of conquering Turks who pushed the limits of their misrule to the very gates of Vienna. In our day a double line of steel rails has succeeded trail and military road, and the smoke of the Orient Express hangs low in the very valley where, centuries ago, dust clouds were raised by the passing of Roman legions, Crusading knights, or Turkish infantry. Here is the vital link in the great Berlin-to-Bagdad railway route, the channel through which German ambition hopes to reach the Far East, and the path by which the Teutonic powers must send men and munitions to the hard-pressed Turks and bring back food to their own hungry people.

Map Showing Barriers and Trenches of the Balkan Peninsula.

Abbreviations. (1) In northern Serbia, etc.: Lo, for Losnitza; Ma for Malyen Ridge; Mi, for Mitrovitza (on the Save); O, for Orsova; Ob, for Obrenovatz; S, for Shabatz; Se, for Semendria; U, for Uzhitze; Va, for Valyevo; Vi, for Vishegrad; Z, for Zaietchar. (2) Along the Morava-Vardar trench; D, for Demir Kapu gorge; Ku, for Kumanovo; L, for Leskovatz; Ve, for Veles; Vr. for Vranye. (3) Elsewhere; Du, for Durazzo (on the Adriatic); I, for Ipek (42½° N. and 20° E.); K, for Katchanik (42¼° N. and 21° E.).

Let us examine for a moment the physical characteristics of the stream-carved trench which has figured so prominently in the past history of southeastern Europe and which again has focused upon it the eyes of the civilized world. The mouth of the Morava valley is widely open to the plains of Hungary, where the Morava River unites with the Danube some miles east of Belgrade. Southward up the river the valley narrows gradually, and the hills on either side rise to mountainous proportions; but as far up as Nish it is mature, with a flat and sometimes marshy flood-plain over which the river flows in a complicated meandering course, with occasional oxbow lakes and braided channels. Only at two points, where the river has probably cut through ridges of exceptionally resistant rock, does the valley narrow to a more youthful form and force the better roads to make long detours over the hills. There is usually ample room for a main road on each side of the river, while the railway crosses from one bank to the other in order to connect with the larger towns located on the valley floor. The river is navigable half-way up to Nish, and throughout the entire distance the flood-plain soils yield rich harvests of maize and wheat.

From Nish the route leads southeastward up a branch stream called the Nishava, to a low divide within Bulgarian territory. The valley of the Nishava is more youthful than that of the Morava and is so narrow in places that the wagon road twice abandons it for a course across the mountains. The railway is able to follow it throughout, however, and in one place the valley widens to a broad basin on the floor of which lies the important town of Pirot. Here fortresses crowned the adjacent hills to guard against a Bulgar invasion of Serbia along this comparatively easy path.

After crossing the divide at Dragoman pass, about 2,500 feet above sea-level, both road and railway descend to the broad, fertile floor of the Sofia basin. Fortunately this trends northwest-southeast and is thus in line with the general course of the Morava-Maritza trench, although it drains to the northeast through a narrow outlet gorge into the Danube. At the southeastern end of the basin the low Vakarel pass, but little higher than the Dragoman, is crossed, and road and railway easily reach the much larger basin drained by the Maritza River and its tributaries.

The Maritza takes a direct course toward Constantinople for more than 150 miles, then turns abruptly southward to the Mediterranean Sea. At this sudden bend in the river stands the fortified city of Adrianople. Except for a short distance below the city, the Maritza no longer serves as part of the great pathway to Constanti-

nople, but becomes a segment in the natural moat, consisting of the Tundja and lower Maritza valleys, which in the past has repeatedly provided Constantinople with an admirable first-line of defense against aggression from the west. Above Adrianople the river is too frequently obstructed with sandbars to be of much use for navigation, but its broad basin carries the road and railway which follow the southern bank of the stream. South of Adrianople the small Ergene River flows to the Maritza from the east, and its valley

Central News.

Italian artillerymen dragging a giant howitzer up a steep mountain trail in the Alps.

offers a very gentle grade which the railway ascends till within a few miles of Constantinople.

THE MORAVA-VARDAR TRENCH.

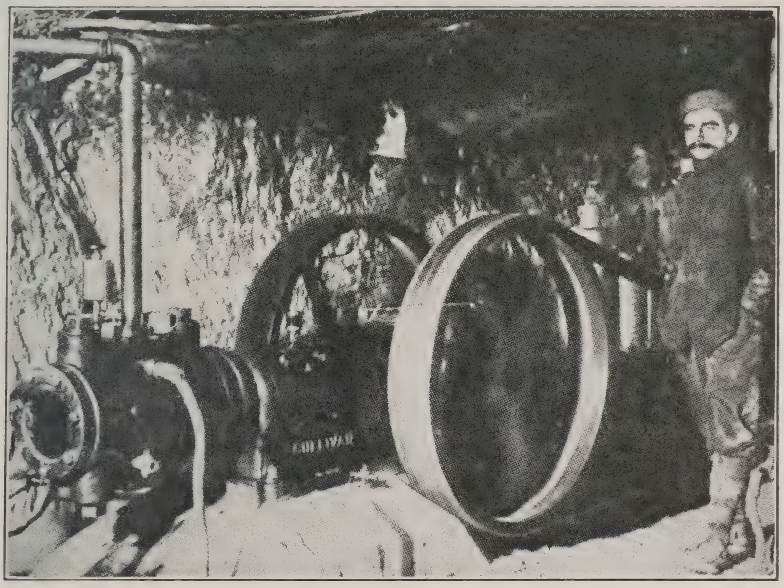
Second in importance to the Morava-Maritza corridor is the deep trench which cuts through the Balkans from north to south, connecting Belgrade with Saloniki. The Morava-Vardar depression does not lead to the land bridge uniting Europe with Asia Minor, but it does serve as a most important outlet channel from the plains of Hungary to the Mediterranean Sea, and is one of the shortest

routes from central Europe to the Suez Canal. From southern Germany and the eastern Alps, the foothills of the Carpathians and the Alps of Transylvania, and from all of the great Hungarian basin, the valley routes lead straight to Belgrade, whence the Morava-Vardar valley cleaves a way through the mountains to the open waters beyond.

It is not without reason that the Morava-Vardar trench has been called the key to the history of the Balkan peninsula. Through it ebbed and flowed the tides of repeated invasions from the dawn of history. Under Roman dominion most of it was occupied by an important military road. Through it the Ostrogoths entered northern Greece in the fifth century, A.D., while names still found on the map of Greece bear witness to the great Slav flood which, two centuries later, flowed through the trench and overwhelmed the Greek peninsula. The story of the Serb race is largely the story of a struggle for control of this vital artery of communication. Austria's ambition to seize for her own uses a channel to the sea which should not open on the inclosed Adriatic has been the mainspring of her reactionary policy in Balkan affairs. Bulgaria, realizing that the nation which dominates the Morava-Vardar depression must ultimately dominate the politics of the peninsula, precipitated the second Balkan war in order to make good by force of arms her claim to a section of the trench; and the same incentive played an important part in determining Bulgaria's alliance with the Teutonic powers in the present conflict. Most of the friction between Greece and the Entente Allies had its inception in the fact that Greece controlled one section of a channel all of which was essential to the existence of Serbia. The Belgrade-Saloniki railway was the main artery of commerce which carried through the trench the life-blood of a nation.

The physical characteristics of the Morava valley as far south as Nish have already been discussed in connection with the Morava-Maritza trench. From Nish southward to Leskovatz, road and railway traverse one of the open intermontane basins which frequently occur in the midst of the Balkan ridges; but farther south the stream flows from a youthful gorge which continues up the river for ten or twenty miles before the valley again broadens out to a somewhat more mature form. Just north of Kumanovo lies the divide between the Morava and Vardar drainage, a low, inconspicuous water-parting some 1,500 feet above sea-level, located in the bottom of the continuous, through-going trench, and placing no serious difficulties in the way of railroad construction.

South of Kumanovo the valley broadens into a triangular lowland, near the three corners of which stand Kumanovo, Üsküb, and Veles. The main Vardar River enters the lowland from the west, flowing out again at the south through a narrow, winding valley which carries the railway, but no good wagon road. At Demir Kapu the valley narrows to an almost impassable gorge for a distance of several miles but soon broadens again to a flat-floored valley in which the river follows a braided and occasionally meandering channel to the sea. The lower course of the Vardar lies in a very



Italian Official Photo.

One phase of mountain warfare. An engine driving rock drills used in excavating a tunnel under Mount Tofaha. By means of this tunnel the Italians undermined and blew up an Austrian fortress on the mountain top.

broad, marshy plain terminating in the delta southwest of Saloniki. The special strategic importance of the triangular lowland near Üsküb and the Demir Kapu gorge will be emphasized later.

While the Morava River is navigable for small boats from the mouth half-way up to Nish, the upper Vardar is too full of rapids and its lower course too full of sandbars to make river traffic practicable. The strategic value of the Morava-Vardar trench, like that of the Morava-Maritza, lies in the fact that, notwithstanding it occasionally narrows to gorge-like proportions, it gives an unbroken channel-way clear through a rugged mountain barrier.

PEACEABLE CONQUEST OF THE MARITZA VALLEY.

The immediate object of the Balkan campaign of 1915 was to secure for Germany complete control of the Morava-Maritza trench and the Orient railway which runs through it from Belgrade to Constantinople. Roughly speaking, one-third of the trench was in Turkish territory, and therefore already subject to German supervision; one-third was in Bulgaria; and the remaining third in Serbia. German diplomacy set itself the task of inducing Bulgaria to become an ally of the Central Powers, in order that the middle third of the Morava-Maritza trench might pass under German control without a contest and in order, further, that Bulgarian troops might bear the brunt of the fighting necessary to capture the remaining third from Serbian hands.

This was truly an ambitious plan, but certain considerations having a geographic basis made it possible for Germany to crown the program with success, and that with slight cost and incalculable profit to herself. The close of the second Balkan war found Bulgaria not only bitter from the disastrous defeat with which her treachery to her allies had been punished, but suffering serious geographical disadvantages from the illogical boundaries forced upon her. Rumania's appropriation of the Dobrudja brought hostile territory close to Bulgaria's chief seaport of Varna and also menaced the safety of the railway connecting with the port, since this line lies parallel to the new boundary and close to the frontier. The natural outlet for all central Bulgaria is to the Mediterranean by way of the lower Maritza River; but the reconquest of Adrianople by the Turks led to a division of territory which forced Bulgarian goods enroute downstream to the Bulgarian port of Dedeagatch to cross through a small section of Turkey. The only other natural channel to the Mediterranean from Bulgarian lands was down the Struma valley to the port of Kavala; but Greece in her turn had insisted on a boundary which should leave the lower course of the river and the port in her hands, thus compelling Bulgarian commerce by this route to pass through Greek territory. Finally, Serbia obtained possession of that section of the Morava-Vardar trench which Bulgaria had coveted, leaving to the latter no part of the key to future power in the Balkans. The opening of the present war thus found Bulgaria with a serious geographical grievance against every one of her neighbors. With coast lines bordering on two seas, every bit of her commerce, save only that with Russia, was forced to pass through hostile lands.

Here was a fertile field for German diplomatic effort, and Bulgaria lent a willing ear to plans which promised immediate redress of past wrongs. Turkey was induced to return to Bulgaria the strip of land west of the lower Maritza, thereby insuring to her a railway connection to her Mediterranean port lying wholly within her own boundaries. As a further reward for direct action against Serbia, Bulgaria should receive the coveted section of the Morava-Vardar trench, the conquest of which would be rendered easy by Teutonic coöperation from the north. It was a bargain in valleys. In return for free use of the upper Maritza valley, and assistance in effecting the conquest of the Morava valley, Bulgaria was to receive a part of the lower Maritza valley and a section of the Vardar valley. German diplomacy won, the geographic bargain was made, and from that moment there remained only the problem of forcibly seizing the Morava-Vardar trench.

NATURAL DEFENSES OF THE MORAVA-VARDAR TRENCH.

While conquest of the Morava valley and its continuation up the tributary Nishava was alone necessary to complete Teutonic possession of the Belgrade-Constantinople railway route, two considerations made a comprehensive campaign against the entire Morava-Vardar trench essential. In the first place, as we have just seen, the Vardar valley had to be secured for political reasons, since its possession by Bulgaria constituted an essential part of the Teuton-Bulgar bargain. But military reasons also required its capture. It constituted the one effective line of communication leading to the Serbian armies defending the northern frontier. To cut it was to deprive those armies of reinforcements, munitions, and other supplies coming from the south. Furthermore, possession of the Morava-Maritza trench would never be secure so long as Serbia and her allies held the Vardar depression, for at any moment they might launch a bolt along this natural groove which would sever the Orient railway at Nish and thus undo all that had been accomplished through the new alliance with Bulgaria. For the Teuton-Bulgar forces the capture of the combined Morava and Vardar valleys was a single military problem. Let us examine the physiographic features which serve as natural defenses of this important trench.

The Morava valley is widely open to the north and is there bounded on both sides by comparatively low hills. An enemy securing a foothold in the rolling country to the east or west could

enter from either of these directions as well as from the north, just as the Orient railway coming from Belgrade enters the valley from the west, twenty-five miles above its mouth. Hence an effective barrier against attack from the north must cover more than the actual breadth of the northern entrance to the valley. Such a barrier is provided by the natural moat of the Save and Danube Rivers which protects the entire northern frontier of Serbia; and by the hills south of the moat which, as one progresses southward, rise into a wild, mountainous highland.

The Save is a large river swinging in great meanders across a broad, marshy flood-plain. The extensive swamplands on either side of the river are difficult to traverse at any time, while the flood waters which spread over the lowland in spring and autumn often make the barrier quite impassable except at Mitrovitza (not to be confused with the Mitrovitza near the Kosovo Polye referred to farther on). South of Mitrovitza and west of Shabatz the marshy peninsula between the Drina and the Save is called the Matchva and is famous for its inhospitable character. In volume the Save is of sufficient size to constitute an obstacle against invasion, but for purposes of navigation it suffers from its overlong meandering course and from frequent shifting of channels and sandbars. At no point is the stream fordable, and at Belgrade alone is it crossed by a bridge.

The Danube is a river of imposing volume, in places from one to several miles wide. Its value as a defense against invasion is very great, notwithstanding that the numerous islands which mark its braided course from Belgrade east to the Iron Gate gorge offer some advantages for a crossing. It is unfordable and unbridged. East of the braided section the river exchanges its open valley for a narrow, winding gorge which cuts through a mountainous upland and reaches its most imposing aspect at the Iron Gate near Orsova. The walls of the gorge, sometimes forest-clad, sometimes bare rock, are exceedingly steep; while the mighty volume of water constricted within its narrower channel gives a river which is both swift and deep. To cross such a barrier in the face of enemy fire would severely test the abilities of the best-trained soldiery.

It is not strange that so impressive a natural obstacle as the Save-Danube valley should have served for centuries as a bulwark against invasion of the Balkan peninsula from the north, nor that it should long have been the physical barrier separating the dominions of the Sultan from Austrian lands. In combination with the difficult

hill country to the south, the great natural moat furnished the Serbians with an admirable defensive screen, in attempting to pierce which the Teutonic armies suffered more than one costly defeat.

Throughout its entire length the Morava-Vardar trench is protected on the east by a complex of mountain ridges representing the western ends of the Balkan and Rhodope masses and the southwestern extremity of the Transylvanian Alps. All of these ranges appear to have reached a mature stage of dissection in which the maximum degree of ruggedness is attained. A maze of steep-sided ridges and peaks rises from one to several thousand feet above the bottoms of narrow valleys, while at the north the mountain barrier is reinforced by the gorge of the lower Timok River and a short section of the Danube valley. Much of this difficult country is forested, and no part of it could be crossed with ease by a hostile army.

There are, nevertheless, certain pathways through the eastern barrier which might be forced by a foe possessing superior numbers. Chief among these is that segment of the great Morava-Maritza trench carved by the Nishava River, which unfortunately rises within Bulgarian territory, and flows directly through the barrier into the Morava-Vardar trench at the critically important junction near Nish. To stop this gap the fortifications of Pirot just inside the Serbian border were constructed. Zaietchar, another fortified town farther north, guards the common entrance to the Tsrna and upper Timok valleys, through which hostile forces might asend to passes whence the drop into the Morava valley is readily effected. The Vlasina, Kriva, and Bregalnitza Rivers, rising at or near the Serbo-Bulgarian boundary on the crest of the range and flowing westward to the Morava and the Vardar, give access to the trench at Leskovatz basin, at Kumanovo, and in the Veles-Krivolak region. Finally, the broadly open Strumitza valley, mainly in Bulgarian territory, but heading close to the lower Vardar, affords access to several passes from which it is but a few hours' march to the Vardar trench either above or below the Demir Kapu gorge.

It appears, therefore, that despite the protection afforded by difficult mountainous country east of the Morava-Vardar line, the trench was open to attack at a number of critical points, provided the invading forces were sufficiently large to overwhelm resistance and drive their columns through the narrow valleys. This danger was the more acute because along much of the eastern frontier Bulgarian territory reaches the crest of the mountain barrier and in

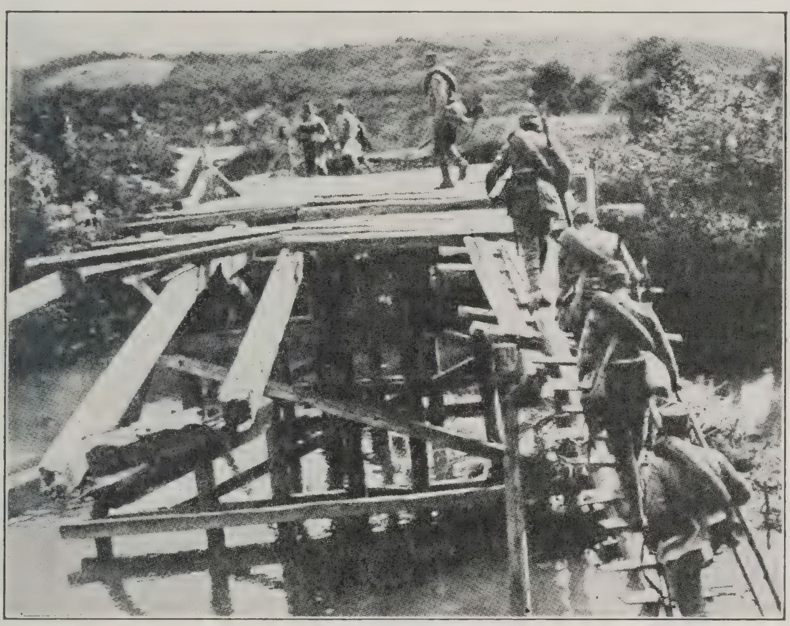
some places even beyond the crest to the western or Serbian slope. It should be noted, furthermore, that the hostile territory flanks the Morava-Vardar trench throughout practically its entire length, usually lying more than fifty miles distant, while near Vranye and just north of the Greek border westward protrusions of the Bulgarian frontier reduce the distance to a dozen miles or less. The largest and most vital artery carrying the life-blood of Serbia lay dangerously near the surface, and a single stab of the Bulgarian knife might prove fatal.

West of the Morava-Vardar trench the threat of danger was less imminent, and the natural protective screen more effective. Although Bosnia and Herzegovina were in Austrian hands, the people were more or less hostile to their new rulers and favorably disposed toward the Serbs. Montenegro was Serbia's ally, while uncertain Albania was not an important factor in any event. Across the Adriatic lay Italy, another ally of Serbia. Only at the north, then, was there danger of an attack upon the Morava-Vardar line from the west; while farther south succor from friends, rather than attacks from enemies, was to be expected from the direction of the Adriatic.

The broad belt of mountains lying between the Morava-Vardar depression and the Adriatic shore is one of the most imposing topographic barriers in Europe. From the earliest times it has stood as an almost impassable wall cutting off the people of central Serbia from all effective intercourse with the inhabitants of the Italian peninsula. In the Middle Ages, Ragusa and other Slavonic cities on the Adriatic coast, although part of the Serbian province and the home of a flourishing school of Serbian literature, found communication with the interior so difficult and with Italy so easy that they came under Venetian instead of Serbian control. The same mountain wall which so long prevented extension of Serbian power westward to the sea, likewise served for centuries as an effective barrier against the eastward migration of western European civilization into the dominion of the Turks. To the present day no railroad has crossed the barrier to unite the great valley of central Serbia with the sea.

Included in the mountainous belt are ranges high enough to carry snow caps until the month of August, and the name "Albania" is believed by some to have its origin in the snowy appearance of that wild region. It is said that the "Accursed mountains" of northern Albania and eastern Montenegro include some of the least

explored lands of all Europe. Just as the mountains of Wales and the highlands of Scotland preserve languages and customs which have been driven from the open country of England, so the fastnesses of the Albanian hills have kept alive a difficult language that is older than classical Greek and customs which render the rude inhabitants of the country a picturesque subject for study. The conquering arm of the Turk reduced the Bulgarian inhabitants of open plains to complete subjection within a comparatively short time; but a century and a quarter was required to secure a less



Serbian troops crossing the Kolubara River barrier on the runis of a bridge which was repeatedly destroyed and repaired during the fighting along this stream.

firm hold upon the mountainous lands of Serbia, while the inaccessible wilds of Albania and Montenegro were never completely subjected to Turkish power. Montenegro was the last Serbian stronghold to yield to Turkish supremacy and the first to regain complete independency.

The physical characteristics of a belt of country so difficult to traverse deserve a word of further description. In the north the mountains consist of much eroded earth folds of the Appalachian type, trending northwest-southeast parallel to the northern Ad-

riatic coast and rising from 5,000 to 8,000 feet above sea-level in the higher ranges. Between the hard rock ridges streams have excavated parallel valleys on the weaker beds, but these valleys are of little real service to man since they lie at right angles to the natural course of his movements between coast and interior. Farther south the rock structure is more complex, and the mountain ridges produced by erosion accordingly of more complicated pattern. Among the rocks involved in the mountain building, limestone is a conspicuous element, and its soluble nature has imposed a peculiarly forbidding aspect on the topography. Most of the rainfall passes underground through sink-holes and smaller solution cavities and then finds its way through subterranean channels to a few principal rivers, lakes, or the sea. As a consequence much of the mountain country is dry and barren, springs are far apart, and the open water courses difficult of access because deeply intrenched in rock-walled gorges. The "gaunt, naked rocks of the cruel karst country" are not only themselves of little value to mankind but they render inacessible and therefore comparatively useless many excellent harbors on the east coast of the Adriatic.

Because the limestones are purer and more abundant along the coastal border we find that the karst topography is there best developed. Farther inland the maze of hills is occasionally broken by an intermontane basin, the center of whose broad floor may be covered by marsh land, while throughout its remaining portion the fertile soils derived from impure limestone and other rocks yield good returns to the cultivator. Among the largest of the basins are those in which Monastir and Ipek are located; the Tetovo basin, west of Üsküb, where an important branch of the Vardar River takes its rise; and the famous Kosovo Polye, or Plain of the Blackbirds, southeast of Mitrovitza, where in its last great effort against the advancing Turk the Serbian army suffered defeat in 1389. It is largely to these areas that one must credit such measure of prosperity as is vouchsafed the dwellers of this western mountain barrier; but absence of connecting lowlands makes the basins of small service in expediting travel across the region.

It is true that certain rivers cut through the mountain ranges to reach the sea; but not one of these has carved a valley suitable to serve as a highway between the coast and the central Morava-Vardar trench. For the most part cross valleys are narrow and deep and bounded by the steep, rocky walls characteristic of young

gorges cut in limestone. Falls and rapids are frequent, and the headwaters usually end in a maze of ridges some distance west of the central depression. The valley of the Narenta carries a narrow-gauge railway through the mountains of Bosnia and Herzegovina to a pass, across which Sarayevo and the valley of the Save are accessible; but the only branch line running east to the Serbian border terminates in the vicinity of Vishegrad, while the nearest railway terminus of the Serbian system is more than twenty miles across the mountains at Uzhitze at the head of the Western Morava valley.

Central News.

A barren basin or ''polye'' in the Serbian mountains. The bad road has caused the cart to upset, with resulting injury to the driver.

Through the gorge of the middle Narenta the course of the railway is difficult, and the crossing of the pass is made possible only by using a rack-and-pinion arrangement, which indicates the unsatisfactory character of the route for commercial purposes. The next river of importance to the south is the Drin, which reaches the sea near Scutari; but it flows in a gorge so wild and deep that the poor trails of the district often leave it for a course across the barren hills. When a column of Serbian troops successfully negotiated this defile during the first Balkan war, the feat was hailed as a great

military accomplishment. The Shkumbi valley offers an entrance from Durazzo to the rail-end at Monastir, but traffic by this route must cross three mountain passes. A famous Roman road, the Via Egnatia, followed this valley, and the only other two important roads to cross the barrier in Roman times had their locations determined by the Narenta and Drin, although in each case the stream gorge was abandoned in places for a more feasible course over the uplands. Of these former roads little remains today except rugged mule paths. From the standpoint of military geography the broad mountain belt west of the Morava-Vardar trench is practically impassable.

There are within this western mountain belt three depressions which have relatively little value as part of cross-routes to the sea, but which we must keep in mind if we are fully to understand certain aspects of the campaign against Serbia. First among these is the open Kolubara valley, at the head of which stands the town of Valyevo. A small railway of some military value traverses the valley and connects the town with the Save River. Directly south across the Malyen ridge, the Western Morava valley heads near Uzhitz and runs east to join the main trench. The Western Morava River is a mature stream meandering on a flat flood-plain of considerable breadth and is bordered by a narrow-gauge railway connecting Uzhitze with the Orient Express line. Finally, the Kosovo Polye, already mentioned, forms part of a subsidiary trench parallel to the main Morava depression. Northwestward the basin is replaced by the long, narrow, winding gorge of the Ibar River, which unites with the Western Morava, but which is not followed throughout its length by so much as a good wagon road. To the southeast the basin is drained by the Lepenatz River, which flows through a narrow outlet gorge at Katchanik, the so-called Katchanik pass, to unite with the Vardar at Üsküb. An important railway leaves the Nish-Saloniki line at Üsküb and runs through the Katchanik gorge and Kosovo Polye to Mitrovitza on the Ibar.

Our examination of the surface features of the region under discussion has developed the fact that the Morava-Vardar trench is well protected against invasion, whether from the north, the east, or the west; but it appears that the most effective protective barrier is on the west, where it is least required and where, indeed, it might shut off much needed succor from Italy in a time of peril. Let us now trace the history of the campaign against Serbia in the light of our knowledge of the topography.

CAMPAIGNS AGAINST SERBIA

Early Campaigns for the Morava-Vardar Trench

Austria's first attacks against the northern barrier formed by the Save-Danube moat and the rising hills to the south were ostensibly made primarily for the purpose of punishing Serbia, while the idea of securing a portion of the Morava-Vardar trench was kept in the background. The first blow in the world war was struck in the last days of July, 1914, when Austria launched a strong offensive along the entire Save-Danube line. The Serbians destroyed the great bridge over the Save at Belgrade in order to make the barrier more secure and assailed with vigor every enemy column which endeavored to cross the river by boats or pontoon bridges. For nearly two weeks the Austrians made repeated attempts at seven different points to reach the south bank and at the same time attacked the line of the Drina near Losnitza and Vishegrad. At Belgrade a crossing in the shelter of the ruined bridge was only temporarily successful. Farther east, at Semendria, an island served as the base for crossing on a pontoon bridge where the channel narrowed to 200 yards; but the invaders were first held in check, then thrown back in defeat. All attempts to cross at Obrenovatz, southwest of Belgrade, failed. Far to the west Austrian troops succeeded in forcing a passage at Mitrovitza and for some days held their ground in the marshes on the south side of the stream; while the Drina was crossed at Vishegrad. Even here the success seems to have been partial and temporary, for Vishegrad was retaken by the Serbs August 7th, and on the 10th the Serbian government reported the expulsion of the last Austrian from Serb territory. The first attempt to force the northern barrier had ended in failure.

A second attempt was made immediately. After a furious bombardment of the Save-Danube line superior Austrian forces crossed the Save at Shabatz and the Drina at Losnitza, while columns attempting to cross at Belgrade were defeated. In the gorge of the Iron Gate at Orsova, where the swift current and steep walls made the attempt peculiarly hazardous, it is said that three Austrian regiments were destroyed while trying to cross by a pontoon bridge. Renewed attempts to cross at Belgrade and Semendria were frustrated. Belgrade stands on the point of a peninsula projecting into Hungarian territory and is subject to attack from three sides. It was the capital of Serbia, and its capture was urgently desired for political as well as strategic reasons. That this important out-

post at the very door of the enemy's country, attacked by superior artillery, should have resisted capture for four months, is a striking proof of the strategic importance of such barriers as the Save and Danube Rivers. Meanwhile, on August 20th the Austrian armies which had entered northwestern Serbia were overwhelmed with defeat after a four-day battle in the foothills east of Losnitza and in the marshes of the Matchva near Shabatz and were driven back across the Drina with heavy losses. Fleeing remnants of the invading force overcrowded the few bridges spanning the unfordable stream and large numbers perished by drowning. A second attack against the natural defenses of northern Serbia had proven futile.

About the end of the first week in November, 1914, Austro-Hungarian armies more than 300,000 strong launched a third attempt to force the northern barrier. The open valley of the lower Drina and the marshy Save River were crossed by superior forces with the aid of heavy artillery. Advancing up the Kolubara valley and the low foothills on either side as far as Valyevo the Austrian center prepared to attack the Serbian position on Malyen ridge, while the left wing occupied Belgrade, and the right wing captured Uzhitze. Apparently the plan of campaign was for the Austrian center and right wing to converge upon the head of the Western Morava valley and then follow down that depression into the main Morava-Vardar trench, thus outflanking the forces defending its northern end. Meanwhile the small Serbian army was giving a good account of itself, defending river and marsh and hill slope with such effect that not until the first of December did the Austrian forces reach the Uzhitze-Valyevo-Belgrade line. A month of desperate fighting with heavy losses had elapsed before the invaders were ready to attack the main Serbian defensive position on Malyen ridge just south of Valyevo.

Then came the stroke which startled the world. Assuming the offensive and sweeping down the slopes of the Malyen, the Serbian veterans overwhelmed the whole Austrian army with disaster. Valyevo was recaptured, Belgrade and Uzhitze cleared of the enemy, and all northwestern Serbia swept clean, except the marshy peninsula between Shabatz and the Drina, where Austrian troops maintained a foothold with the aid of topography especially favorable for defense. The upper Drina was crossed by the victorious Serbs, and Sarayevo seriously threatened. A badly beaten Austrian army retired to Austrian soil, to have its commander officially disgraced for the crime of failure. Whether because of difficulty in bringing

adequate supplies across the marshy Save and over the foothills to the Austrian front, or because the Austrian forces had been unduly weakened in their month's campaign against the Serb defenses, or because the difficulties of the Malyen position were underestimated and troops were detached to serve elsewhere, a third attempt to force the natural protective barriers of northern Serbia had ended in a costly defeat for the Teutons.

It was now evident that Austria, with many of her troops engaged on other fronts, could not assemble forces competent to dislodge the Serbians from their favorable defensive position. At the same time the need of controlling the Morava-Vardar trench was increasing. The Central Powers were besieged by the Allies, and an outlet to neutral lands and to the sea was a pressing necessity. The Turks needed munitions and the Central Powers needed food. A successful campaign was also required to wipe out the disgrace of past defeats at Serbian hands and to impress wavering neutrals with Teutonic military prowess. Hence was initiated the diplomatic campaign already described, which culminated in the peaceable conquest of the Maritza valley and the accession of Bulgarian troops to the ranks of the Central Powers. Conditions were now ripe for a combined Teuton-Bulgar campaign designed to conquer the entire Morava-Vardar trench.

THE CONQUEST OF SERBIA.

Early October, 1915, found some 200,000 Germans and Austrians massed on the Save-Danube line, while a larger number of Bulgars were concentrating in the mountains along the eastern border. The main Serbian army stood behind the northern defensive line to meet the Austrian-German attack, smaller forces alone being detailed for operations on the east. A Bulgarian offensive was to be met by the Greek army acting in concert with an Anglo-French Expeditionary Force. At the last moment the whole scheme of Serbian defense was shattered by King Constantine, who repudiated Greece's treaty with Serbia and refused the promised support of his army. The entire length of the Morava-Vardar trench was thus thrown open to flank attacks from the east while the main Serb armies were trying to protect the northern entrance.

On October 6th the Austro-German assault was launched. Heavy artillery fire, which the Serbians could not match, protected the columns attempting to force a passage across the river barrier. Nevertheless, the crossing was a costly undertaking; many of the

invaders were driven back to the north bank or caught on the south side and annihiliated, before large forces after two or three days' hard fighting securely established themselves on the southern bank. It is interesting to note that the principal crossings were effected above Belgrade, below Belgrade, at Semendria, Ram, and Gradishte, —all five of them points close to the northern entrance of the Morava valley, all of them except the last located at the end of Hungarian railways capable of bringing supplies directly to the points of crossing, and all of them near sandbar islands in the river which were utilized to good advantage in several and possibly in all cases. There also was heavy cannonading at Orsova, the only other railhead on the Danube frontier; but no crossing of the difficult gorge near the Iron Gate seems to have been made until later, possibly after threat of envelopment caused withdrawal of the main body of defenders from the northeast corner of Serbia. When the crossing was effected it was with the aid of an island in the river below the town.

After the Danube barrier had been forced, the southward progress of the Teutonic armies was remarkably slow. For six weeks the average rate of advance was about one mile a day. Despite their enormous superiority in big guns, it cost the Austro-Germans much time and the loss of many men to drive the Serbs from successive defensive positions in the hills. More than two weeks elapsed before the Danube was freed from the Serbian menace and so rendered available for boat transport of munitions to Bulgaria and Turkey. Austrian forces crossing the Drina near Vishegrad, the only rail-end on the northwestern frontier, found themselves unable to dislodge the Serbs from the mountain fastnesses, and after ten days' fighting had made no progress toward the head of the Western Morava valley.

THE BULGARIAN ATTACK.

Meanwhile Bulgarian armies poured through gaps in the eastern mountain barrier and descended tributary valleys to the Morava-Vardar trench. One column descended the Vlasnia valley to the Leskovatz basin, another reached Kumanova and Üsküb by the Kriva depression, while a third descended the Bregalnitz to Veles. Vranye, Kumanovo, Üsküb, and Veles, defended by inadequate Serbian forces, were captured within less than two weeks, and the vital artery of Serbia cut in four places. Few could doubt but that these wounds would prove fatal.

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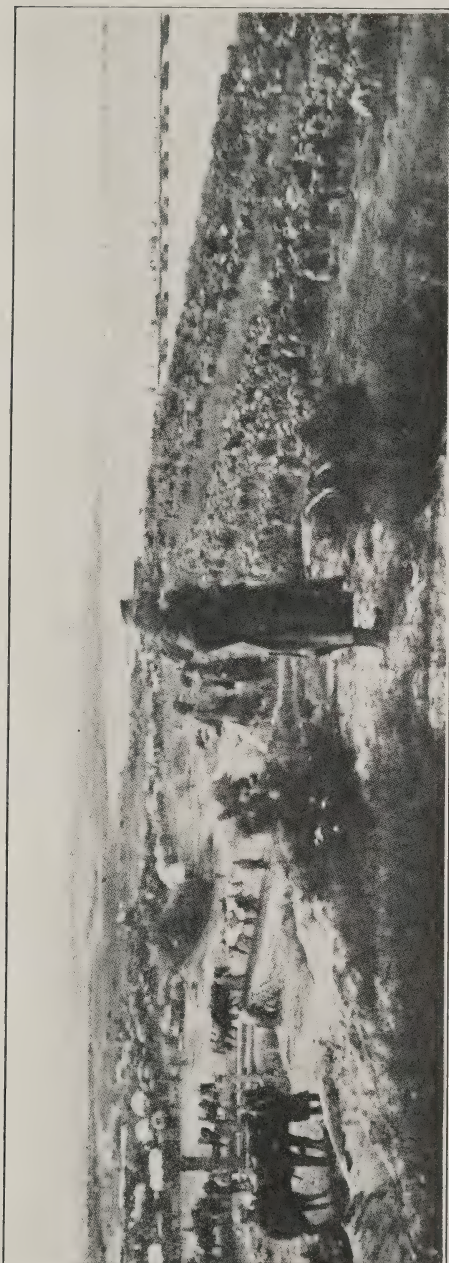
A Serbian convoy retreating through a norraw section of the Morava valley north of Nish.

Farther north one Bulgarian army was attacking the fortifications of Pirot in order to open a way down the Nishava valley to Nish, while other forces had captured Zaietchar and were trying to push up the Tsrna and the upper Timok to reach the Morava trench above and below Nish. Progress in this field was much slower than farther south, however, and the Serbs maintained themselves in the mountainous northeast corner of their country until the fall of Pirot and Nish developed the danger that Bulgarians pushing north down the Morava and Austro-Germans advancing up the valley to meet them might close the neck of the salient northeast of the trench and capture the forces fighting there. Under pressure of this threat the Serbs withdrew to the southwest; and about November 13, or more than a month after the campaign opened, the entire Morava-Maritza trench was in the hands of the Central Powers, and the reconstruction of the Orient railway could be prosecuted. The Morava-Vardar trench as far south as Veles was also in their control, and there remained only the problem of rendering the tenure of both trenches secure by pushing the Serbian and Franco-British forces west to the Adriatic and south to the Aegean.

The disastrous results of the Bulgarian occupation of the Morava-Vardar trench now began to be more manifest. Munitions and other supplies for the Serbian armies in the north were becoming exhausted, and the one artery along which they could freely flow had been severed. The quantities which could reach the Serbian front over rough mountain trails were utterly inadequate. Reinforcements were sadly needed; but the one railway leading north from the Anglo-French base at Saloniki followed the Morava-Vardar trench, and so was in the hands of the enemy, while the rough mule paths over the western mountain barrier could bring neither troops nor supplies from Italy. Had the broad belt of mountain and karst intervened between the Morava-Vardar trench and the Bulgarian frontier, and had the more open valleys of the east but led westward to the Adriatic, the history of the Balkan campaign would have been very different.

THE BATTLE FOR KATCHANIK PASS.

It was supposed that when the Austro-German forces reached the higher mountainous region bordering the Western Morava valley and it became difficult if not impossible to bring up their heavy guns, the rate of advance would become even slower than before. The fact that the advance was actually accelerated has been



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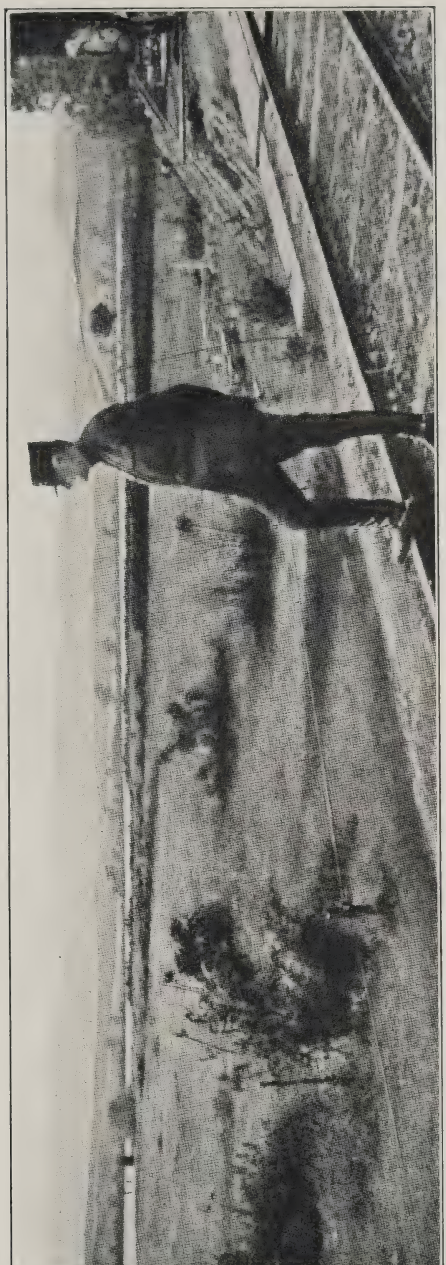
A portion of the Austrian Army halted on the north side of the Save River barrier. Temporary military bridges are seen in the distance.

interpreted to mean that the failure of Serbian supplies weakened the defense more than the unfavorable local topography injured the plans of the offensive. The Teutons moved rapidly across the Western Morava, and the Serbian army took up a position running eastward along the mountain crests south of the valley, then southward along the ridge west of the Morava-Vardar trench, and south westward across the Katchanik gorge. It will immediately appear that the Katchanik position was the strategic key to this entire battle front.

In the rear of the Serbian armies facing north and east, runs the straight subsidiary trench formed by the Lepenatz valley, Kosovo Polye, and the Ibar valley. The gateway to this trench is the narrow Katchanik gorge. A railway from Üsküb runs through the gorge to Mitrovitza at the north end of the Kosovo Polye, thereby more than doubling the strategic value of the depression. If the Bulgarian forces already in possession of Üsküb should succeed in breaking through the Katchanik gorge into the plain of Kosovo, they could strike north and east against the rear of the Serbian armies and convert retreat into disaster. Little wonder, then, that the "Katchanik pass" figured so prominently in the war despatches during this period!

But if Katchanik was the key to the Serbian position, Veles was the key to Katchanik. Should the Anglo-French troops coming up the Vardar from Saloniki capture Velse and debouch into the triangle lowland to the north, they would take in the rear the Bulgarian army trying to break through the Katchanik position. It would be necessary for the Anglo-French force to enter the Lepenatz valley; the mere threat of inclosing the Bulgarians in the valley between the Serbs up at Katchanik and their allies down at the valley mouth would be sufficient to bring the Bulgars out of the trap in order to fight on the lowland, where, if defeated, they could retire northeastward into a region fully under their control. The threat would become imminent the moment Veles fell to the Allies. Such were the topographic relations responsible for the rather striking fact that an Anglo-French attack upon Veles relieved the pressure upon Serbian forces in the mountains far to the north.

The strategic value of Veles was fully appreciated by the Bulgarian commanders, and heavy reinforcements were evidently poured into the Vardar trench at that point. All efforts of the Allied armies failed to achieve their purpose; Veles remained in Bulgarian hands and Bulgarian attacks on the poorly equipped



General Sarrail surveying the Vardar trench near Krivolak, north of the Demir Kapu gorge.

Serbs defending Katchanik gorge proceeded without serious interruption. When it became apparent that the Katchanik position could not long be held, the Serbian armies at the north and east fell back toward the Ipek basin, while those farther south retired on the Monastir basin. All danger to the Teutonic occupation of the Morava-Vardar trench north of Veles was thus removed, and the remainder of the campaign consisted in squeezing the remnants of the shattered Serb forces and their Montenegrin allies westward through Albania and southward through Montenegro to the sea; and in driving the Anglo-French army and the Serbs near Monastir back upon the Saloniki defenses. The first of these movements progressed with exceeding slowness because of the difficult character of the country; and the terrors of the Serbian retreat over rugged mule paths and through wild mountain gorges in the cold and snow of winter can scarcely be imagined. But from the standpoint of strategic geography the second movement alone merits special consideration.

THE ARMED CAMP ON THE TSRNA

When the French and English pushed up the Vardar valley toward Veles they seized as their base for a great armed camp the triangle of mountainous ground lying between the Vardar River and one of its tributaries known as the Tsrna, the latter a stream which must not be confused with the river of same name emptying into the Timok in northeastern Serbia. The position had certain topographic advantages which enabled it to be held for a long time in the face of superior forces; but suffered from one serious disadvantage which ultimately compelled its evacuation. Both the mountain ridges and the river trenches afforded admirable natural defenses. The gorge of the Tsrna is steep-sided and the stream unfordable. The only practicable bridge, a few miles above the river's mouth, was destroyed by the French after they had failed in an effort to move westward and join the Serbs, who were fighting at Babuna pass to prevent the Bulgars from getting into Monastir basin. For defensive purposes the larger Vardar River, protecting the east side of the triangle, was strategically important, because it is both wide and unfordable and its valley is steep-sided,—in one place a veritable gorge.

But it is in the Vardar valley that the chief disadvantages of the situation become apparent. All munitions and other supplies, as well as all reinforcements for the armed camp, had to come from Saloniki over the single-track railway running up the Vardar

French camp in the broad valley of the Vardar River of the Demir Kapu gorge.

trench. The railway lies close to the river all the way and for several miles is actually on its eastern bank, or outside the triangle. Its position was thus dangerously vulnerable, and its vulnerability was peculiarly aggravated by the fact that in the Demir Kapu gorge, the Iron Gate of the Vardar, the line is squeezed in between the base of high cliffs and the swiftly flowing river, crosses the river on a bridge at one point, and passes through a tunnel at another. If the Bulgarians, attacking the sides of the triangle, should destroy bridge, tunnel, or narrow road-bed in the gorge, the forces within the triangle would be caught in a trap. Hence it was that when the dispersal of the Serb armies to the northwest had so far progressed as to free additional Austro-German and Bulgarian troops for action against the Allied armies at the south, the evacuation of the triangle was considered imperative.

It has been estimated that at this time the forces of the Central Powers in the south probably outnumbered those of the Allies in the proportion of three to one, or even four to one. That the triangle should have been held so long in the face of greatly superior numbers bears eloquent testimony to the strength of the natural topographic barriers formed by the Tsrna and Vardar Rivers, as well as to the efficiency of the French who mainly were responsible for its defense. The British line now ran eastward from near the Demir Kapu gorge, along the ridge north of Lake Doiran and south of the Strumitza valley and, like the French triangle, was supplied by one single-track railway. The Serbian front in the Monastir basin ran from west to east just north of the town and connected with the French along the Tsrna River side of the triangle. It also was dependent for supplies upon a single railway line. The French triangle was thus a prominent salient projecting far beyond the general Allied front; it possessed a vulnerable point, the Demir Kapu gorge, on the east side of the salient; and it was the center of a line the two wings of which were less effectively protected by natural barriers and all of which was inadequately supplied with lines of communication.

Early in December the withdrawal from this dangerous situation began. The French retired from the triangle and blocked the gorge against pursuit by blowing up the tunnel and bridge. The British were forced back toward the southwest by a series of furious Bulgarian assaults, and the Serbs were compelled to withdraw southward into Greek territory. The retirement was completed when the Allied armies fell back on the natural defenses of

Natural defenses of the armed camp of Saloniki.

Saloniki. The great armed camp based on this important port was securely protected by two lines of physical barriers, either of which could have been rendered practically impregnable. Inasmuch as this camp was to harbor a mighty army for years instead of weeks, and inasmuch as the failure of the Teutonic allies to attempt the task of driving the armies of Sarrail into the sea was probably dictated more by a knowledge of the formidable nature of the natural defenses than by any respect for the sham neutrality of the pro-German Constantine, we may profitably trace the two defensive lines and note what topographic obstacles they presented to a Teutonic offensive.

NATURAL DEFENSES OF SALONIKI

The outer line begins west of Saloniki on the marshy delta of the Vardar River, and follows up that unfordable stream for a distance of forty-five miles to Amatovo Lake. This part of the river's course is a network of braided channels between changing sandbars, and in places the flood-plain is marshy. From the southern end of Amatovo Lake to the northern end of Ardjan Lake is a stretch of twenty miles where the barrier consists of the Vardar River and the parallel lakes, with intervening stretches of marsh land. Rivers, lakes, and marshes continue the formidable natural moat northward, eastward, and southeastward, with only one insignificant break, all the way to the Mediterranean at the Gulf of Orfano. The Ayak River, Lake Doiran, Kodja Su and Butkovo Rivers, Butkovo Lake, Struma River, Tahinos Lake, and its short outlet river, together with the marshy shores of the lakes and marshy flood-plains of parts of the rivers, serve to make the long curving trench an imposing obstacle. The difficulty of the terrain is enormously enhanced by the fact that just inside this trench, and forming its southern rim, is a curving ridge of high hills, the Krusha Balkan and Beshik Mountains. From the sea to the Vardar valley these hills offer admirable artillery positions which absolutely dominate the valley trench and all places where a crossing of rivers, marshes, or lakes might be attempted. The northern slope of the hills, toward the enemy, is steep and forbidding; the general slope toward Saloniki is easily ascended so that the defending forces could manœuver to advantage. Along the Vardar above the worst marshes and below the first lakes is perhaps the most vulnerable part of this line from the standpoint of the topography; but fortunately this is the part best supplied with railway and road communciations with the base at Saloniki.

Within the outer line just described is one much shorter, consisting of the east-west trench containing Langaza and Beshik Lakes, and the connecting rivers and marshes, and extending from near the Gulf of Saloniki to the Gulf of Orfano. Like the former trench, this one also is dominated from the south by a long ridge of hills. The lake shores are marshy, and the only practicable passageway through the barrier, between the two lakes, is commanded by the artillery positions on an isolated mountain just south, which guards the gateway like an impregnable castle. Farther west hill country intervenes between the marshy shores of the Gulf of Saloniki and Langaza Lake, and intrenched positions here would be fully protected by the guns of the Allied fleets lying in the gulf. To afford adequate protection for the city of Saloniki the line would need to be prolonged westward to meet the Vardar River.

The strength of these natural positions is too obvious to require any special emphasis. Behind such barriers so great an army as was here assembled could withstand the best that the Kaiser and his allies could send against them. The western arc of the outer perimeter was not seriously threatened, and the Entente forces were not required to retreat within the inclosure in this sector. But around Lake Doiran the fighting was bitter, and farther southeast the Allied armies took refuge for a time on the southern side of the Struma trench. The most important service, however, rendered by the natural defenses of Saloniki to the Entente cause was in forcing the Kaiser to close the Balkan campaign near the border of Greece instead of on the shores of the Mediterranean, the Teutonic armies might with impunity defy the ostensible neutrality of Greece and capture such Greek cities and fortifications as they chose; but the barriers of nature, when fortified by a great army, they could not defy.

OLD AND NEW OPINIONS ABOUT THE VALUE OF PERMANENT AND FORTIFIED POSITIONS.[1]

(*Continued from No. 52.*)

The last three citations lead us naturally to Schlichting and his opinions as to the value of fortresses and fortified places of every kind and description. And here it is to be observed that Schlichting treats the subject from a historical standpoint, and in the development of fortifications aims to appraise their importance under modern conditions. He makes the same limitations as does von der Golz in the last citation but one as to the degree of advance in civilized conditions in the present day, especially as regards the extent and facility of intercommunication, such as is afforded by the network of avenues in the present field of operations. The richer a region is in these, so is there less demand in general for fortresses; the poorer and scantier they are, so much the greater becomes the practical value of the others. This gives to his views, whether we agree with them or not, whether or not they be admitted as demonstrated, a coloring all their own, distinctively subjective in character. Throughout he sets up the strictest operative and tactical standards as his guide. He has no predilection for fortresses and fortified places in themselves as such, but only regards them as worthy of consideration as they contribute to the successful carrying out of operations, or serve an auxiliary purpose in the conduct of a campaign.

The subject is gone into most thoroughly by Schlichting in his well-known, "Tactical and Strategical Principles of Today." It is characteristic of his method that the article on "fortresses" comes under the head of "command or leading of troops," and in the chapter is included a portion treating of operations. The artificial strengthening of land defences is treated of in a chapter devot d to tactics in field service, and constitutes a part of the section, which has to do with the influence of terrain in the art of war. This is ac-

[1]From *Schweizerische Zeitschrift für Artillerie und Genie,* June, 1917. Translated from the German by Maj. Henry Swift, Chaplain, U. S. Army, ret.

companied by a military-historical sketch, an appendix to the article on fortresses, in which he undertakes to establish the relation these bear to active strategical operations.

This sketch, as a preliminary, discusses the conservative character of fortresses, and their relative importance during the time of Frederick the Great, in the Napoleonic period, in the war of liberation, during the wars from 1854 to 1866, and in the Franco-Prussian war of 1870-1871. His conclusions are embodied in the propositions that follow, in whose formulization Schlichting's own experience in the last mentioned war appear as the most weighty determinant:

(*a*) Upon field maneuvers depends the issue of a campaign; and for these the armies operating should be as strong as it is possible to make them. Large bodies of troops held in inactivity for purposes of land defence obviously militate against this end.

(*b*) France, in its great operations, has been detrimental to itself in expending its energies over the maintenance of its fortresses. These would probably have been in better condition had their garrisons been weaker in proportion. Only Paris, the fortified central point, could be counted as of supremest importance, while the fortresses on the northern line, for any practical benefit they served, were but of doubtful value, even local.

(*c*) In great field operations dependence upon strongholds should be avoided as much as possible. Fortresses, however, that are along water lines of communications possess a recognized value, if they lie within the sphere of operations.

(*d*) Fortresses, if a vigorous resistance is counted on, must be extensive and massive. If with the ordnance of the present time—the book was written in 1898—the attack is made with artillery effective from every direction, its range from the initial attack reaching to the very center of the place assailed, they are helpless. Only fortresses that have a wide outspread girdle of subsidiary works may fulfill the purposes and conditions of defence.

(*e*) If it is found that there is needed a constantly increasing force for their defence, it becomes necessary then to exercise the greatest discretion in the selection of such strategic points. In sections that are highly developed along the lines of civilization, with elaborate systems of intercommunication, such available points become ever more difficult to select.

Concerning fortresses in general, he makes the following remarks:

"Fortresses must be massive and strong, and occupying such

positions relative to each other that an invading army will not be able to march past them, but must be constrained to invest them with much heavier forces than the defenders will be obliged to employ.

"It may be said in passing that this kind of gigantic fortification, from its very nature, is forever in need of amplification and elaboration. With the considerable amounts expended upon it, there increases appreciably the sense of its importance: for the governor of such a stronghold, being intrusted with the expenditure of a portion of the national resources, comes to have a conviction of the necessity of outlays on the particular section under his control that is oftentimes entirely disproportionate. As the custodian of such a charge he always requires more to perfect it There is always here and there some eminence that commands and threatens the defences; or on his front is some section that is relatively weak; and so another fort must go up to protect or to strengthen the position: and then comes the need for further expansion, until the greater part of the periphery is included. Where there has been such a growth as is seen, for example, at Strassburg or Metz, their radius of protection has come to embrace a very extensive area, as any mathematician can easily figure out."

Those who recall the beginnings of the erection of our Gotthard fortifications will recognize the correctness of the above conclusions. There the initial constructions were moderate, and the projectors were content to follow the plans as originally contemplated; and then, after a while, one thing brought on another. "Weight was added to weight." As a result each addition to the original plan suggested another, until today it becomes a serious question where and when the work will really reach a conclusion.

Where Schlichting discusses especially the French system of fortifications, which has developed since the war of 1870-1871, the external ring of fortresses and their subsidiary outworks close to the frontier, the more elaborate fortified constructions back of these, and then the central fortifications of Paris, he speaks to the following effect on the subject of outer forts (Sperrforts):

"In the first place it must be perplexing to the laity, the uninstructed, to find that on one side the necessity exists for extending and amplifying the great strongholds in order to give them a proper degree of defensibility and resistance against modern artillery, mo-

bile as it now is; and at the same time that forts of lesser size must be erected in great number about the same in order to assure the defence of the approaches. One can hardly blame his inexperience for failing to be convinced of the necessity of carrying out such a double system, where there appears to be a contradiction in terms.

"There may be built on some mountain passes outer forts, of no greater magnitude than many an old baronial castle, which by virtue of their position are practically unassailable. On the whole, however, the system can hardly figure on erecting a defensible fort of such character at every approach to the more developed parts of the country (Kulturland): for it is to be presumed that the invader will be sufficiently prepared by a sudden movement to brush away such relatively small obstacles—otherwise the whole theory of the strengthening and extension of the great defensive works is based upon a fallacy. One or the other of the propositions must be false, if both are not, and the art of defensive construction finds itself today in a critical position. The sudden fall of several of this kind of minor erections predicates with certitude the weakness of the whole chain. There prevails among some the idea of reviving the ancient cordon system over a fortified region. Places like Bitsch, Königstein or Silberberg hardly appeal to us for their multiplication. The Chinese wall has this fault, that it is easy to pierce at any point." . . .

Schlichting is at his best in his treatment of the relation borne by fortresses to operations, and their importance as obstacles in the way of hostile movements, as also the part they serve as a support, as appears in the following extracts:

"A campaign resolves itself into separate events, in which operations within narrower limits pass under one's observation. The losses incident to such side issues may make very considerable drafts on the strength of a command. The extent of these in 1870 during the investment of Metz were only possible under the system of defence pursued by Bazaine's army of the Rhine. Under the conditions then existing the attainment of the main object of the campaign, that is—the subjugation of the central stronghold, could not well be realized so early as 1870. It would, however, be a capital error to conclude from events as they occurred that the art of fortification had been proved to be superior to strategy. In due course of time the central point, that is the capital, learned

its lesson. The fate of the country and the issue of the campaign was not affected by the resistance offered by its defences. The question was really decided before as much as after the battle; and they had just cause to repent who had staked their hopes of success on the massing of heavy forces within the line of their fortifications.

"His embarrasments are still further increased, if the defender feels compelled to regulate the movements of his operating forces with reference to the location of his fortified posts, relying on the latter as a support or supports for his wings, whether in front or rear. It may readily be granted that occasionally such accessories might furnish effectual tactical support; although it has but seldom occurred in the experience of military history. The value of such aid bears no proportion to the disadvantages occasioned in the way of operative restrictions, by hampering the field army in the freedom of its strategical dispositions. Freedom of movement, as opposed to such limitations, is always more advantageous; and hence the fortress Sphinx of which the press in earlier days discoursed in forceful terms, is forever submitting her enigmas to be solved in the planning of any series of operations.

"Of the same character must be the conditions with which the offensive of an army in the field must have to contend if they seek to protect their rear in the homeland by heavily garrisoned and numerous fortresses. Such conditions are by no means unexampled, as the so-called Quadrilateral of upper Italy (Festungsviereck) serves to illustrate. Such adjuncts show themselves of value only as they dominate a contracted belt, such as lies between the Alps and the sea. Whether, and to what extent, they would serve a like purpose in open country abundantly traversed by first-class roads is something that only the experiences of a campaign could decide. At all events Vauban's system has recently been shown up as inadequate.

"For operations in defence of one's own territory there can no longer be placed any reliance on its fortresses as a base. As an auxiliary they may be of worth if they happen to lie within the field of operations. Who could fail to recognize the value, for example, of the Rhine fortresses, such as Strassburg, Mayence, or even Cologne. Still they may not be pivotal or determinative of military movements. They are so many instruments or tools to avail oneself of, if they are in the way, or fall within the area of operations as contemplated: and so, while they may fit in with the purposes

of a campaign, the latter must not be dependent on the fortress, nor have its course modified by the fact that such a place exists. The war of the present day counts upon all the auxiliary resources of the country that lies back of it (das Hinterland), and finds its natural objective in the opposing frontier. It also relies with the greatest confidence on the channels of communication, which are the circulatory system, veins and arteries of the sum total of its resources, and most of all does it depend on the railroads. There still linger, however, traces of the idea of the importance of fortified depots or magazines, an idea which cannot emancipate itself from the feeling of the necessity of fortified bases; and always with the word is associated the tradition of earlier times, without being able to interpret it by the light of present conditions.

"Those who are obsessed by the theories of the past, that have become obsolete, are disposed to maintain the fortress system in its entirety, or to ascribe to some single point an importance altogether disproportionate. But nothing is more perilous in defensive war of the present day than the disposition to confine and concentrate operations about some one point considered as especially strong. Such centralizing of a section, whether with or without fortifications, brings with it an almost inevitable promise of disaster."

Thus Schlichting, as was Napoleon, is of the opinion that one must not permit himself to be conquered in consequence of a too obstinate dependence upon fortresses. It is all right to avail oneself of a fortress, if position and circumstances fit the case; but operations are not determined because of, so much as notwithstanding, their proximity. The efficiency of military movements depends upon the mobility of the army in the field, and upon its capacity for delivering an attack, and not on the walls of strongholds nor on armored forts.

Such was the teaching of Napoleon, which in 1866, as well as in the war of 1870-1871, was followed and constantly maintained by von Moltke. And above all things it must never be lost sight of that Schlichting belonged to an army, in which the offensive was the inspiration of its leadership, which maintained persistently the rule of a constant strengthening of its active forces, and availed itself of every improvement of war appliances.

And yet what might be true for certain phases of war does not necessarily apply to all conditions. The comparitively weak forces of a state, whose main policy is the preservation of a strict neutral-

ity, must shape its military preparations on other lines. Here a strategical defence becomes its principal rôle. In such an instance objections and cavilings need to be thoroughly examined into (winnowed) and, it may be, explained away. The importance of fortifications, whether of a permanent or temporary character, assumes an entirely different aspect. And on these grounds it is interesting to hear what Schlichting has to say concerning the intrenched camp, as well as the use of the spade in field operations.

While for a long time he had fought against the idea of the intrenched camp, his principal contention was "that it would be difficult to carry out in scientific form the ideal of a fortified camp in the heart of a region highly advanced in civilized appliances." In order to instance a practical illustration from his point of view, there seemed to be only two that he could offer: first, one belonging to the past, the Camp of Bungelwitz; and the other belonging to a more recent period, that of Plevna. Of this latter he writes:

"Plevna was in very fact a fortified camp, and its loss after a most stubborn defence practically decided the issue of the war. We need to set forth the circumstances which shaped the conditions. The position is one of the most important keys, or avenues of approach and communications in Bulgaria, in a country but little developed in culture, and with roads of the poorest. After the establishment of the camp there, this point became the most important in the theater of war. Osman Pasha succeeded in securing it in his retreat from Servia after the successful advance of the Russian army into the Balkan region. The nature of the country lent itself admirably to the establishment of a defensive position, while it effectually blocked the invader from further offensive operations. For quite a while this worked all right: but when not the slightest offensive was attempted by Osman Pasha, and no relief appeared, he finally succumbed as did Bazaine at Metz, and Vercingetorix in Alesia. Notwithstanding the military glory which the brave Turk earned by his determined resistance, there is little call, as may readily be conceded, to imitate his methods in the heart of civilized states. There conditions but seldom favor such a system of defence. In the former instance the lack of good roads counted for much. Thereby every cross-road becomes a point of indispensible value, as its possession opens at least one, and sometimes two lines of operations.

"The whole war would have to assume this complexion, and systems of fortifications and intrenchments would come in fact to

be of the supremest importance. We see in the Balkans the Pass of Plevna serving as a key to every fork road in the country from the Lom to Lowtscha, presenting an effectual barrier to any hostile advance. For capacity of offering a stout resistance, of withstanding every attempt at an offensive, there were in the position conditions at every point favoring a passive defence and presenting difficulties that were well nigh insuperable. There was also this additional advantage in favor of the adversary, that they had secured a position on the Russian flank, which had of necessity to be won before any offensive operations could be inaugurated in the Balkans. At the same time the Russians were handicapped by their failure to provide a proper siege train. They made but an unskillful use of their light artillery, attempting in their offensive to capture with only a field equipment positions which up to the very end proved to be superior to regular fortresses in their impregnability. Finally, however, the commanding genius of a Todleben was applied to the triumphant accomplishment of the task.

''The Russo-Turkish war of 1877-1878 has contributed rich material toward the study of the Art of War. It has served to supplement and round out effectively the lessons learned from our own experiences in the wars of 1866, and of 1870-1871. But with it all no conclusive arguments have been advanced for the establishment of fortified camps in regions of advanced civilization. The difficulty lies in the easy accessibility of any strategic point within the theater of war, where it might seem advisable to make such a camp. The artillery of the present, on account of its range, weight, rapidity and effectiveness would call for an ever increasing extension of the works; and these again would require complete organization for their defence. But all these might prove to be a hindrance rather than a help, if success is to be looked for with an operating force. Therefore it would seem, with conditions being what they are with us, that we should modify our notions about fortified camps. With limitations they might to a degree prove to be of advantage in places where naval co-operation may become available, as at Torres Vedras, Sebastopol, Düppel or Alsen.''

From the tenor of Schlichting's work it must be recognized that he is writing only with reference to the conditions of the German army and territory. On the grounds he takes, then, there appears to be a certain amount of importance attaching to fortified works

like Plevna, and in the Turkish custom of strengthening points where there is a junction of highways, which would be equally true of our own mountain conditions: for in the mountains there is as a rule a great poverty of communication, and the control of a pass will either block or serve to facilitate operations.

Notwithstanding his refusal to consider the necessity of fortified camps in developed regions, Schlichting, reasoning from the experiences of the Russo-Turkish war, does not hesitate to acknowledge the importance of previously prepared positions in present-day tactics, and to commend their study.

"In the vast extension of the lines, by reason of the great operations carried on today, where one command must control the entire field, there will sometimes be one and another portion of the army, for which the ground must be prepared, as where positions have been won, and it is necessary to keep in touch with contiguous commands: and here it is that the engineer comes in with his field fortifications, where there cannot be too great care taken in the planning and execution, whether it be in exercises, maneuvers, or in the urgent necessities of a campaign."

We, who are of the infantry, have in our time made much of Schlichting, copied him, taught him, constituted him our pattern and authority. This was well as far as it went, although in our own military devisings we have been constrained to diverge from his teachings, where our uniform neutral policy and the paucity of our forces have imposed upon us peculiar conditions incident to the defensive. And yet, unfortunately, to the last cited utterances of Schlichting there has been accorded none at all, as at the best a languid interest, mostly academic in character: and yet he has underscored his position as shown in the following passage:

"And so it is the duty of the engineer to be right at hand beside the Commander on the battle field, where in some dominating position the varying fortunes of the conflict may be noted with alert and trained observation; so that he may handle his material with the greatest dispatch, and under the direction of the general lay out such lines of intrenchments as are called for. The spade has a part to perform in modern tactics, which gives to it relatively as great importance as the actual arms of combat. The strengthening of defined positions for a prolonged resistance against an offensive will at times be more effectual than to depend upon the stay and support of a system of permanent fortifications; and even in at-

tacking the spade will serve on some parts of the field to husband forces that may be employed for other and more critical emergencies. *Since this is so, the science of the attack of organized positions has attained such great importance.*

It is to be regretted that conclusions of this character, although they command a verbal acquiescence, have not been given their due proportion of attention in actual practice.

On the whole it is evident that with Schlichting it is a foregone conclusion that, as a rule, defensive operations must not in general be made to depend on fortresses, and for decisive actions in the field they should not enter into calculation at all. No matter what may be urged of advantages possessed by those holding the defences, as opposed to the disadvantages confronting the adversary, he is ever ready to instance the experiences of 1866 at Königgrätz, and of Metz, Sedan, and Paris in the war of 1870-1871.

"They are detrimental to the defender, and advantageous to the assailant. At Königgrätz and Sedan this was so evidently the case that no words are needed for its demonstration. They spake loudly enough for themselves; for they only prevented any freedom of movement on the part of those who held them, and thereby enhanced the mobility of their adversaries. Not a single movement of the latter could the fortress obstruct, but it made the investment of the defensive army all the easier. The outcome of the battles about Metz was similar, although the fortifications here for a time retarded the reaping of the immediate fruits of victory; on the other hand they served as a trap for the besieged. The battles about Paris consisted of a series of unsuccessful sorties."

So skeptical is the stand taken by Schlichting against the value of permanent fortifications, as well as of the fortified camp; so unreservedly has he declared himself in regard to the construction of artificial land defences; and in the manipulation of his own army corps, especially in the maneuvers at Donauschingen in the Fall of 1894, he gave a practical demonstration of his theories. His views and ideas as to artificial strengthening of positions and the employment of the spade find their ultimate expression in this passage.—

"If it is desired to strengthen a position, whether for the offensive or defensive in order at the same time to assure the victory by an overwhelming display of force at another point, then the art of field fortification becomes the means to the end."

"In every battle of greater magnitude, while the offensive may be the principal end in view, there may always chance to be some part of the field where a defensive attitude must be assumed; and while in our opinion the rule may not hold good for the whole extent of the front, in such a particular section tactical recourse to the spade is called for, although no predetermined rules may be laid down for its employment. In the war of 1870 our adversaries were so thoroughly wedded to a defensive policy, that in every engagement they would utilize and intrench quickly and skillfully every clod and hummock that offered itself, while the German infantrymen regarded and performed the spade-act when required more as drudgery. Ducrot, after his retirement from the disastrous sally at Champigny before Paris, left behind him well defined intrenched lines marking his battle front, which showed but few marks of a severe handling. The inability to extend these arose from the constantly increasing menace to both of his flanks, and eventually to his rear.

"The tendency in one and the other army, as described above, represents extreme views. A true policy lies almost always midway. The spade is a useful help to an offensive spirit, while on the other hand it may constitute for the defensive in its overuse a positive peril.

"Fortifications for the support of long-extended lines of operation back of the front were used by us in the year 1866, and our opponents were similarly protected. For such a purpose were constructed the field-works at Dresden and at the bridgehead of Florisdorf, and initial steps were taken also for the laying out of works of this character on the Nuthe and Notte (confluent tributaries of the Spree) south of Berlin. Circumstances so happened that there was no occasion for the tactical employment of these on either side, and in the war of 1870 conditions were practically the same. And yet the possible usefulness of fortifications was never lost sight of, as it was felt that an emergency might arise that would demand their employment. There might be some station on the lines of communication, or some mountain pass threatened, of such importance that it would be necessary to have defences, that might be manned by small garrisons. Ordinarily the necessity is most imperatively felt for the establishing of such works at bridge-heads in operations that contemplate commanding the approaches at a critical point, thus maintaining control of the stretches of the stream which the said crossing dominates. Where a tactical neces-

sity exists for such a protected crossing, then the bridge-head will serve as a fulcrum strong and reliable for the operations on the field of battle.

"When the operations at such a point will have attained their maximum of effectiveness, then the measures taken for defence will furnish an additional and secondary support, as by the aid of such works there may safely be a reduction of the forces defending the bridge-head, not to speak of the economy in minimizing losses, thus saving the strength of the command."

It is evident that such a spirit as Schlichting, so all-embracing in his treatment, discussing as he does all technical improvements and innovations in the course of his essay, would not fail to take up the matter of Schumann's armored towers, as well as the employment of heavy ordnance in actions in the field. His views on these are here given:

"If the opinions as presented are agreed to, then the introduction upon the field of battle of heavy guns (Position-*geschützens*) and of the Schumann armored towers is of very limited value. Certainly the first-named would add much to the formidableness of an attack, while the other would contribute greatly to defensibility of the section where employed. Both, however, depend upon the mobility and the capacity of an army to convey such weighty constructions, whose burden must never be to it an impediment. It is more than doubtful whether, if even despatched beforehand by the use of every means of transport available, they could reach their destined positions in time. The congestion of roads on a march to battle becomes very considerable, especially after the fighting has begun along the front; and as the leaders of the various units find these machines following them there will be calls and orders from every side, and it will not be long before those who are transporting them will find themselves trailing along in the rear of the columns, or by-and-by, perchance, a clear day's march behind.

"The difficulty is always to be apprehended that such ponderous accessories will interfere with the speediness and promptness of movement so all-necessary in the conduct of a battle, and that on the whole they will prove to be a clog on the development of the engagement, without there being any certainty that they will be able to supply the aid expected of them at the right time and in the right place. The consideration of this proposition, when all is

said for and against the importance of such appliances in the wars of the future, would doubtless give rise to objections of no little weight. If such sentiments prevailed, then the question whether the enemy defences might be more readily shattered by guns of high trajectory, or whether by means of armored towers the defensibility of one and another point would be increased, would become matters of subordinate interest. There would always be the question as to the ability to co-ordinate operations, to assemble the individual elements of these cumbrous accessories without their becoming at the same time a source of weakness, especially if an equally alert enemy were avaling himself of the same appliances. On the other hand, if the enemy should abandon the open field in order to intrench himself with one of his armies, or it might be with his col-trench himself with one of his armies, or it might be with his collective strength, on some plateau like another Vercingetorix in Alesia, or Osman Pasha in Plevna, or in fact as the French attempted to do at Gravelotte-St. Privat, then the call for these engines and defensive appliances would assume a character of far greater importance.''

In conclusion we quote a few comments and remarks of the same writer in regard to mounted forces:

''We have so far excluded cavalry posts on a large scale from the discussion for they are veritable traps, and unless succour comes to them from without they might fall an easy prey to the enemy. In closing, then, we will accord them a special treatment.

It is, first of all, essential that the ground occupied by cavalry should be well protected, the works assuming the character of the strongest possible fortifications. Against such defences the assailant must have time to make his preliminary arrangements for destroying obstacles before he can advance to the direct assault. The whole question in a modern battle resolves itself into that of fire superiority as against any and every kind of fortress.

The struggle for fire-superiority assumes this form before every fortress. The invasion of the land, with which this article is especially concerned, requires that siege material should be at hand as quickly as possible. In advance of this should be placed such equipment as may be required for the field attack against prepared positions. In the field operation this forms a second échelon which, in case of need, can be drawn upon more speedily than the siege train.

"To burden a command in actual operations with these is impracticable, and it is not probable that the day will come when heavier ordnance, such as is used in the equipment of fortresses, and armored towers will be employed in the field. Such speculations may serve well in theory, but in the actual experiences of practical warfare they have no place."

The position taken by Schlichting as to fortresses, fortified places, field fortifications, and the technicalities of their assault, as well as their adequate defence, are too interesting and too defiant in tone to permit their being passed by without their being tested by the current events of the present war. These events and illustrations crowd upon us in every detail as we pass them in review.

And in the very first place it is evident, that what Schlichting has maintained as to the value or worthlessness of fortresses as factors of support in operations has not only been affirmed by the events of the first months of the war in the western zone, but also in the subsequent occurences on the eastern front during the period of 1915 and 1916. Neither the Brialmont fortified regions in Belgium, nor the fortified camp of Warsaw, nor the Russian triangular system of fortresses in Poland and Volhynia, nor the fortified chains of the Nieman and the Narev were able to present an obstacle to the advance of their adversaries nor were they of any assistance to them in their own operations.

In every instance the great efficiency of the ordnance department in providing implements of destruction has enabled the artillery of the Central Powers to crush the stoutest armored dome, the firmest concrete construction, demolishing them completely. On the other side—that is, the French—it was rather the field works at Verdun than its permanent defences which demonstrated what could be effected by such agencies in conjunction with a mobile army in the field, ready as they were to make every sacrifice in order to win. With the Russians there was an almost complete dependence, as far as its staff was concerned, upon their fortresses, and even after the rehabilitation of their artillery they gave up as a rule on the very first thrust. So also has it fared with the conduct of the Roumanian army about Bucharest.

With the ever-growing importance of field intrenchments in military operations Schlichting's views have been amply endorsed, although it was hardly possible for him to have anticipated how, with the prominent place that the use of the spade has assumed, that there should be the handling of such enormous masses of men,

or such a vast extent of ground covered. Still, as has been indicated before, there is unfortunately one point where his teachings are not followed, where there is indeed a wide departure from his views, and that is as to the importance of fortified places for purposes of defence.

[Note by translator—

A few geographical notes are here appended for information where maps may not be easily accessible:

Alsen is an island in the Baltic, formerly Danish, now German; scene of conflicts in 1848 and 1864; fortified since 1870.

Düppel in Schleswig-Holstein, forming a bridge-head for the defence of the island of Alsen, to which (at the town of Sonderburg) it lies opposite; scene of military activities in 1848 and 1864.

Lom, a tributary of the Danube.

Lowtscha—Lovcha (Lovatz), lying on the Osma, south of Plevna, a town of some 3,000 inhabitants. This place was captured by Skobeleff, thus cutting off Osman Pasha's communications.]

In contrast with Schlichting we have Bernhardi, in his time military attaché of the German Embassy in Bern, a man eminently modern. In his book, "Wars of Today," he discusses with keenest acumen the more recent theories of the Art of War, and in his exposition has placed on record the importance he attaches to land defences and fortified strongholds. He goes more fully than do Schlichting and von der Golz into the principles of mass formations (*Massenprinzip*), and the necessary deductions therefrom. To this he is unreservedly committed, every proposition according therewith, and with it maintaining the necessity for the utilization in military operations of systems of land defence and of fortified places.

According to Bernhardi, land fortification is more than ever called for, as much for attack as for purposes of defence, playing as it does a most important part, and being largely determinative of the issues of a war.

According to him one should not regard fortified works, as is too commonly the opinion, as exclusively means for defence—that is, for a passive resistance. "It would be a vital error," he says, "if one would estimate the importance of fortifications by such a narrow criterion.

"As war itself, out of simple beginnings, has developed the battle into a mighty and complicated mechanism, so also has the fortress since lost its character of being merely a shield for some

particular section and an adventitious aid. Today it has rather acquired a high degree of importance in the elaborate details of a campaign.''

Where strategically their main purpose is for defence purely, as is generally the case in time of war with such states as are pledged to a strict neutrality, fortresses distributed along the border will very materially aid their armies in resisting a threatened invasion. ''They not only will protect a considerable area, but will serve at the same time as supports for flanks, and as shelters for depots and supplies.

''On the other hand, if the army is forced to retreat, then will such fortresses act as a check on the enemy, divert him from a forward movement, and serve as a very serious drag on his offensive. This view carried to its ultimate consequences would contemplate the establishment of a line of frontier fortifications, presenting practically an unbroken and mutually supporting front. While a section covered by an isolated fortress might be cut off, it would be perfectly feasible to so organize a border defence system that every point could be under the fire control of the guns as against any invasion.

''Certainly such a system might be likely to abound in faults and weak spots, a thing almost inevitable in so wide-extended a cordon, and it could well be the cause of a wasteful distribution of forces along a front in positions where they could be of no assistance in determining the issue of an engagement. To a certain degree this serves to establish such a defence as a whole upon a faulty foundation.'' It is evident that the system he has in mind is that which has been followed by France in her outer ring of frontier defences.

''The simple factor of the protection afforded a particular region is not to be undervalued. If manufacturies of military munitions are established in a city, and possibly magazines of supplies, or if within the area there are important railway centers, or railroads or other commercial highways bridging principal water-courses, the necessity for their protection is manifest, that they may be under every circumstance secure in their activities, plants, operations, and for every purpose for which they have been designed.''

"Finally, the moral effect of the secure holding of any section of country makes its fortification for defensive purposes a matter of prime necessity. If by some mischance in the present war between Germany and France, Strassburg—for instance—were to fall into the hands of the French, this would be for them a great material triumph, and in addition possessing a moral value of far-reaching importance, not only from a military point of view, but in the entire arena of international politics, while it would prove to be a severe blow to the prestige of Germany."

Apart from what has been quoted above, Bernhardi agrees with Beseler, who was formerly chief of the Bureau of Fortifications, and was also in charge at the siege of Antwerp, as well as that of Novo-Georgievsk in the present war, in his opinion that the loss of a fortress does not necessarily become decisive of the issue of a war. "The fate of a nation cannot by any possibility depend upon the retention of any one paticular spot, however important it may be, or be regarded."

Even the fall of a capital city is not for Bernhardi vital. "If France, after the fall of Paris, had still had a considerable army in the field, her resistance would not of necessity have been obliged to terminate." So also the taking of Pretoria by the English was not determinative of the South African war, although that city was the capital and the only so-called stronghold in the Transvaal. The Boers kept up the struggle for fully two years after its capture. "The soul of a nation must have received a mortal stroke before the victory can be assured. For such an event, however, the occupation of a fortress can be decisive only under exceptional circumstances, and even then it is only mediately and not directly affected by such an occurence." And here again is where the mass principle comes in again, for he says: "Where the entire strength of a great commonwealth is mobilized for the battle, where the appeal in these modern days is to the levy in mass, then the issue can never be dependent on the fate of one particular section of the country, because the strength of a nation is never in any wise restricted to one locality, and its defence pure and simple becomes a question of time and endurance, and will never be terminated by any one single event.

"Only a war energetically prosecuted, in which all forces are engaged, where eventually all ranks are enrolled, can decide the

victory or downfall of a state.'' Today, more than ever before, does the event hang upon the issues of field operations, and not on the struggle for the possession of a fortress.

Bernhardi, however, makes one exception to this general principle, an exception which especially applies to the conditions as they exist in Switzerland.[1]

''One exception, perhaps, is to be made in the case of minor states, where the capacity for resistance is concentrated in one local point. In a war against Belgium the capture of Antwerp would most evidently be conclusive, and in Switzerland the Gotthard fortress, with its outlying mountain system of defences, embracing Lake Lucerne must become of most vital importance.''[2]

''In great countries the war-deciding importance of a fortress is a thing of the past; and were an army to desire to confine itself for defensive purposes behind the shelter of wall and ditch, the genius of modern warfare refuses to recognize such a disposition.'' And so it is not only considered possible, but is laid down in orders—''to make the land-defence system auxiliary to field operations, and above all in aiding an offensive.''

Upon the outbreak of war it is the business of the land-defence, first thing of all, to stand on the purely defensive. The border fortifications serve in this period as a shield for the frontier; certainly not—''as a line of barrier forts, or like another Chinese wall, but as a protecting agent for important highways, for railroad centers and junctions, for the crossing of streams[3], and for mountain passes.

''The sooner this protection becomes effective so much the more effectually will they help sustain the border rangers in their difficult and multifarious duties. The defensive system of works insures the guarding of the entire frontier, it directly safeguards important points and stretches, it is able to furnish substantial aid when required to the border troops, and always can supply reserves.'' This capacity for serving the mobile forces is most strikingly exhibited in the present war along the Italian front. It is, in fact, their permanently constructed system of border defences that has enabled the Austrians to prevent up to the very present time

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1 (*Unsere Verhältnisse,* literally ''to our conditions''; the writer is a Switzer).

2 (*Vierwaldstättersee,* the Lake of the Four Cantons, Lake Constance).

3 (*Flussübergangpunkte,* which may be either bridges, ferries or fords.—S)

any invasion of their territory by the Italians. The fact that so long a period elapsed before the outbreak of war between the two countries was an added factor in favor of Austria; for it gave her the opportunity to put in thorough condition the lines, which before that had been only provisionally constructed and equipped.

Border defences have also their part to play in an offensive, although in the present war this has never been effectively demonstrated. ''First of all, defensive positions afford a secure base for the mobilization and concentration of the forces; and then, after this has been accomplished, the gates are open for an undisturbed invasion of the enemy's country, especially where streams and large rivers constitute the boundary line, or flow at no great distance therefrom. The critical moment for crossing a stream or river will be, by favor of ample wide-controlling bridge-heads, if not insured complete immunity, still largely protected against the perils incident to such a movement. A safe and undisturbed passage under such conditions is the first step toward a vigorous offensive.''

But, according to Bernhardi, the offensive value of fortresses covers a still broader field. ''If the assailant figures on advancing with heavy columns against a particular point, in order with superior forces to engage in battle there, he can only hope to win in such an offensive, the enemy having equally-matched or even greater forces, by drawing on his own strength from some other point. At this weakened sector he must endeavor to avoid any decisive action, restraining the adversary as much as possible either by refusing a strategic wing, or by maintaining a stubborn skirmish action aided, it may be, by favorable conditions of the terrain.

''And this is where the fortress comes in to help. From its very constitution the conditions are such that a much more considerable body of the enemy is needed to invest it, than of the other side to defend it. On strategical fronts, also, which must be held with a minimum of effectives, the fortress provides a substantial means of defence, and makes it possible under certain conditions to add to the strength of the forces engaged at the crucial point.''

''This problem, however, can be satisfied only when it actually succeeds in engaging the attention of the enemy with considerably greater forces than are needed to garrison the fortress; if they do not leave it unassailed, or provided that the adversary does not content himself with a simple investment, leaving only a compari-

tively weak force sufficient to keep the garrison tied up. In such cases the fortress must assume an offensive to such an extent as to compel the enemy to bring against it a larger draft from his main body; and in addition to this, it must seek to cover objectives, whose possession would be of great operative value to the enemy, so that he must be compelled to put forth every effort to possess himself of them. The last is accomplished by wisdom in the selection of points to be fortified, the first by the application of all the resources of the art of fortification and equipment.''

This view is illustrated by two examples. The first is Strassburg; because it is a bulwark against any offensive of France in the direction of southern Germany, dominating as it does most effectually the crossing of the Rhine. Its capture and possession would prove of the highest moral value, and have considerable influence on the outcome of the war. The second is Breslau; because this commands the crossing of the Oder, and—were it a fortress—would not only protect the connections of the Germans with their Austrian allies, but would also flank every Russian offensive directed against Berlin, and with its power to strike with even a moderate force it would compel the enemy to make heavy drafts on his strength, even necessitating the withdrawal of troops from important points in the North. And so it would not only greatly relieve a German offensive from Brandenburg (Mark, the March, March of Brandenburg) or Prussia, but it would also serve, in union with Cracow, as a most powerful fulcrum and flank support for an Austrian offensive from the South. ''But should the Russians at any time, in conjunction with the Poles and Czechs, make common cause against Germany, then would a fortress at Breslau serve, not only for the protection of Silesia, but in case Silesia were lost it would be a very essential instrumentality in the reconquest of that province, provided Germany could hold it long enough.

''So the fortress may serve in many useful ways as a pivotal point in an offensive, especially for the country that is numerically weaker; and it will often, though indirectly, prove to be a weighty factor in obtaining the victory.''

As an added testimony to the general importance of border fortifications we quote a passage from Beseler's work: ''The Engineer's Art and the Offensive,'' which fits in very well here. ''The border fortress must deliver to the enemy a peremptory 'Halt!' if its own defeated army, after an unsuccessful offensive, has been

compelled to retreat. The stronger the fortress system is, the more capable of delivering heavy blows, so much the more effective check will it impose upon the enemy, so much the greater toll will it exact from the strength of the enemy's forces tied up by it, so much greater a relief and breathing-spell will it give to its own—for the time being—defeated army. At such a moment time counts for everything. Not within the walls of the fortress, as the insidious and often misunderstood teaching of the intrenched camp would seem to inculcate, but by the help of the fortress itself shielded and recuperated, the army has a chance to reorganize, to gather fresh forces, and to resume the offensive as occasion offers. The land defences afford the army opportunity, not to renew or take a share in the combat behind the shelter of wall and ditch, but to put to its best use the open field, to acquire mobility and freedom to maneuver, and thereby ability to resume eventually the offensive.

According to this one may assume that Bernhardi is not, any more than Schlichting or von der Golz, a friend or admirer of the intrenched camp. It is all-important that this should be kept in mind. When Ernst started the construction of our own (the Swiss) defences, commencing the first line in the Gotthard district he advocated strongly the establishment of an intrenched camp, and it was not very long before many others were obsessed by the same idea. People dreamed of an intrenched camp in the valley of the Reuss[1] where, when necessity demanded, the field army could take refuge in order to reorganize and reestablish itself. But in the computation it was not considered how the field army should be provided for in this little valley with its scanty resources, and still less that such a disposition would become a problem for the whole Federation, particularly affecting the plateaus and foot-hills. Truly it exhibits a pleasant prospect for the balance of the state. While the field army is being cooped up in its intrenched camp, short of provisions, freezing, waiting for some auspicious opportunity to turn up, the enemy would be occupying the plateaus, which would afford splendid camping ground for his forces.

[1] "*Urserenthale*"—I can find the word nowhere in books at my command, and have ventured to translate it by the "Valley of the Reuss." The stream that gives a name to the valley flows through the canton of Uri into Lake Constance. The valley, though narrow, is fertile, considerably used for grazing, and is the seat of several munition plants. The principal canton—Bern—is immediately contiguous to Uri. S.

Bernhardi goes further than Beseler, and in his opinion the limitations of the other as to the purposes and employment of frontier fortifications do not satify conditions. ''They alone would hardly divert or occupy so great a force of the enemy as to compensate for the actual casualties and the loss of morale, which may have been suffered in the engagements of the offensive campaign. In fact, the border fortresses can only succeed in opening out to the defeated troops a more unrestricted range for maneuvers, whereby they may be enabled to resume in time the offensive, if the bulk of the hostile forces are brought by their (the fortresses) agency to a halt. This is only to be counted on where there exists a chain of mutually supporting works, or in face of a strongly intrenched and fortified barrier to a stream-crossing. If on an open boundary there are just a few important points converted into strong holds, then there will be ways and means for the enemy to break through the intervals between.''

Bernhardi accordingly maintains the necessity for a second and interior line of fortresses and advocates that which France in her defensive system has actually accomplished.

''An inner line of defences, garrisoned by comparitively weak detachments of the army, would serve to arrest and hold the main strength of the enemy, and in this second stage of the war would give freedom to the defence in its strategical operations to employ the bulk of forces for a telling offensive.''

The experience of war has shown explicitly that Bernhardi is in the right, the Verdun fortifications offering the best example. It is true that in the first stages of the war they did not prevent the Germans from pushing on to the Marne. It remained, however, during this campaign period in the hands of the French, a constent menace to the German left wing, beside being actively operative against the rear of the German armies across the Aisne. Later on it drew heavy German columns against itself, holding and occupying them for an entire year, they making fruitless assaults in the vain attempt to conquer it; and this gave the French command the opportunity for the first time to assume the offensive along the Somme, the Aisne, and in the Champagne.

Because of this the interesting—to Switzerland most interesting and vital—question will be raised: whether in time of peace the second line of fortresses should be kept in such permanent state of defence as the border system, which from the first moment after the declaration of war becomes the scene of active operations.

This is answered as follows: "While the border fortification is under all circumstances of use, the occasion may arise when the fortress of the second line is also of great practical value, though it may not in every instance be the case. Indeed there may be only a few points, which under all circumstances will be of importance, and will retain this importance as critical elements in operations. It depends largly upon what direction the invasion of the enemy may take. Finally operating points of this kind do not need to possess as great a capacity of resistance as must the frontier fortress, which must be prepared to put up a month-long, nay, a year-long defence, if it would fulfil its purpose. Port Arthur, which may be classed as a border fortress, affords a striking instance; while on the other hand Liao Yang was not strong enough to serve as an element in the operations about that city, that is, it was unable to extend to the Russian army relief and support."

In response to this inquiry comes Bernhardi in the following passage: "Probably the best solution of such a problem is this: that places, which beyond any doubt, and under any and all circumstances are important centers in a struggle against a hostile invasion, should be permanently fortified; while other points, which only under peculiar and exceptional conditions would be of value, should, apart from some skeleton groundwork, be only provisionally fortified, being equipped, however, with the necessary supplies of artillery and ordnance. As an example, for Germany we might instance Main and Magdeburg. They belong to the first class of operative centers, which for the resumption of an offensive by a—for the time being—defeated army would under all circumstances be figured on as a strategic center."

This proposition of Bernhardi's is, as has been already indicated, of noteworthy application to our own system of defence and of frontier protection. It certainly provides for the combination of permanent with provisional fortifications. The one thing needful is that all departments or branches of service should be united on a definite programme, and that everything should be prearranged in time of peace in every detail—and being so established that their handling should also be provided for. And here is where the engineer, the artillerist, the leader and staff must work hand-in-hand. It will not do for each to be riding on his own hobby-horse, proceeding off-hand in his own department, without taking the other elements into consideration: in this experience is surely our teacher.

The strategical defences proposed by Colonel Rothpletz in his day, elaborated subsequently by Licht, were the first steps in the direction of such a permanent-provisional system. The plans proposed by the engineer corps of preparations for land defence, plans which were not, however, accepted, were on the same lines. It makes but little difference how much the very best projects are approved and extolled; as a rule they remain simply projects, as was once the case with the defences at Murten and Hauenstein tunnel[1]: for years it was all experimenting, digging, leveling, and then re-intrenching anew.

In common with Beseler, Bernhardi demands in the fortress the greatest possible radius of activity. It must possess a most extensive sweep, as well as the ability to deliver crushing blows; that is, by means of long-range guns in its outworks, and by reserves of transportable pieces, it must cover the greatest possible area. "Such a wide-spreading control of the outlying region is, from an operative standpoint, among its most imperative requirements, so that the fortress should be on the whole as effective for an offensive as for a defence. In addition to this its impregnability must, by every resource of technical skill, be such that it will make every draught upon the strength of the adversary who desires to subdue it. There should be no economy in the use of armored towers or cement work, and the artillery outfit, both in quality and quantity, should be of the latest and best. There should also be laid in a most abundant store of provisions and supplies of the very best quality, so that the lack of these may never necessitate a capitulation at such a time, when the holding of the place must be of the greatest strategical importance. If Port Arthur could only have held out a few weeks longer, probably the whole issue of the war would have been very different."

It should be most impressively laid down that no power should permit itself to be beaten by sheer overweight in the matter of fortresses; that is, a fortress must not, in the endeavor to make it formidable to the last degree, be so immense—"that an over-considerable portion of the nation's strength, needed elsewhere for service in the field, must be tied up in such a place, in order that its works may be effectively manned." "The idea of army fortresses constructed on such a scale that they must require an army to hold

[1]The "*Dictionnaire Grande*" is the only authority giving partial light. Hauenstein is a famous tunnel some 30 km. distant from Basle. Murten is a town in Germanic Switzerland.—S.

them, or that they may afford to a beaten army both shelter and quarters, is open to grave objections.'' The fortress should serve as a support for an army, but not a shelter. Bernhardi instances as a warning the cases of Paris and Metz in the war of 1870-1871.[1] All of the attempts of Trochu and Bazaine to break through the chain of investment were shattered: because such a battle had necessarily to be in the nature of a frontal attack, and under the circumstances in such a case it was, and will always be, difficult to bring a prepondering force to the point that is to be assailed.

''In the erection of a fortress it is all needful to keep a check on oneself as to over-dimensions, and not to be too easily persuaded, in order to gratify the people of a section, to pass beyond due bounds. To contemplate the establishment as fortresses of all the great cities would be in the direction of crippling the military strength of a dominion, while the defender of a stronghold should never be permitted to open its gates to a beaten army, that they might make of it a permanent abode, which would be a detriment to all of the active forces in the field. It must always be categorically maintained that the fortress is an operative point and not a bomb-proof.''

Particular emphasis is laid by the writer on the fact that nothing can be more deleterious and impracticable than half-measures in the construction of land-defences. ''Warning is especially given against a one-sided, incomplete erection, both exteriorly and interiorly, of forts of every kind and description. Outer forts for the protection of river-crossings and bridge-heads have only a satisfactory value if they command, in addition to direct defence, the enemy's approaches. A bridge-head fort which can only offer resistance to a direct attack is hardly worth the money that has been wasted upon it. Every flanking movement, as is always in the capacity of a victorious adversary, diminishes the value of the defences; and the loss of time, hardly worth speaking of, involved in such a movement will hardly ever atone for the moral depression, which the loss of a defensive work signifies. *Half measures are scarcely ever so detrimental as in the sphere of land-defences, because here the injury they are productive of is permanent.*''

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[1]Sedan might also be instanced. The best delineation—although in fiction—of the fortress as a man-trap will be found in Zola's story of the siege of Sedan in the ''Debacle.'' The book is well worth reading as a military document.—S.

In his discussion of the importance of fortified positions Bernhardi has made good use of the examples furnished by recent wars, in which they were largely employed, and historically developed. His exposition presents us with a good military-historical survey, and is for that reason well worth the study.

In the Russo-Turkish war of 1877-78 the Russians intrenched themselves on Shipka Pass, the Turks at Plevna, where they mocked all attempts, as they sheltered themselves behind their works, of the enemy to force their position. Plevna became emphatically the focal point of the war. After this bulwark fell the resistance of the Turks crumbled to pieces; the battle about this point being decisive of the war.

In the South-African war the Boers at all times intrenched themselves, and thereby sought to secure to their weak lines the maximum of resistance. The frontal attacks of the English against these works were almost invariably repulsed. But as the latter persisted doggedly in their attack, the final result was the failure of the defenders to maintain their positions.

In the Russo-Japanese war, finally, the Russians made use most extensively of field-works, expending material upon them with reckless prodigality. In the face of these defences the Japanese offensive won their ground with the utmost difficulty. The advantage seemed to be entirely on the side of the defensive, but their earthworks proved in the end to be as little effective as those of the Turks in the war of 1877-78.

Bernhardi draws from these the following conclusions:

"The chief gain in the war of spades is that of time. The Russians in Manchuria, in their struggle behind the intrenchments, gained time for corps after corps to be drawn from European Russia, until forces had been assembled considerably in excess of those of the enemy. Despite it all, however, they failed to win.

"It was the same with the Turks in Bulgaria. The fortified position at Plevna for a long time withstood the attacks of the Russians. The Turks, however, did not understand how to profit by the time so gained, where every opportunity was afforded them to make successful counter-attacks upon the enemy. Finally the Boers, thanks to their intrenched positions in the hills, were able to prolong the contest for a year longer, hoping in vain for a European intervention.

"In none of these instances were the fortified positions instrumental in gaining the object of the war; that is, of course, to insure victory. Nowhere did the assailants pour out their life-blood so lavishly before defensive works as to compel the other party to yield. On the other hand, sheltered as the latter were behind their intrenchments, the losses they inflicted upon their adversaries were excessive. Every attempt to take by storm was repulsed. The most supreme efforts had to be put forth to conquer, as was eventually done, the intrenched lines; and had the defence availed itself of conditions as they were, there might have been an entirely different issue to the struggle, at least in Eastern Asia and in Bulgaria."

All this leads Bernhardi to inquire—"Why it has happened in every instance that such a stout defence behind wall and ditch has been ineffectual in determining decisively the event; and again, whether the offensive, by a direct attack upon such works, has done all that was necessary to insure a speedy victory, and the strategic crippling of the adversary."

At Plevna it was not the excellency of the works that made their defence possible, so much as the lack of intelligence in the manner of attack. In spite of every defect in equipment and tactics, the Russians outnumbered their enemy nearly three to one, while in artillery they were six times as strong; and surely they would have become masters of the situation had their troops been effectively handled, had they been properly disposed against more vulnerable points, and had they been brought up in the proper formation. On the other side, the Turks permitted all the time they had gained to be wasted, without making on the whole any serious attempt to profit by the excellent opportunities afforded them. And so the mediate, but real and most valuable advantage which their stout defence of their works assured them, namely—the chance to win a decisive victory at some other point was never utilized by them, nor did such a course seem to have entered into their calculations."

"The Turks," says Bernhardi, "failed in good judgment in not expending every energy in profiting by the favorable conditions which their position at Plevna procured them, with every advantage on their side after their obstinate defence of their position, and the opportunity afforded for a successful series of operations."

He reaches a similar conclusion in his review of the South-African war.

He also shows that fortified positions must be attacked in order to be made effective. In most cases only the complement of an offensive is of actual importance. However, neither the experiences gained in the South African war, nor those gained at Plevna can be considered as proof of tactical power of resistance of fortified positions, because these positions were never properly attacked.

His comments on the Russo-Japanese war are essentially of the same character. There, as at Plevna, the hopes of the victorious outcome were based on the defence on the mere holding of their lines, instead of availing themselves of the opportunity afforded them by an offensive initiative elsewhere. At the best their object seemed to be merely to hold the Japanese in check; but even this they failed to accomplish; for notwithstanding the numerical inferiority of the Japanese, as well as their unquestionable deficiency in material and equipment, the Russians were time and again forced to abandon their positions by movements and pressure on their flanks, which movements were frequently combined with direct frontal attacks.

The general conclusion arrived at by Bernhardi in his examination and comments is that the value of fortified places is at all times only relative. "The main thing is the gaining of time; but even here the advantage only appears if the fortified position effectually ties up the forces of the enemy, and if the time so gained is properly employed, so that under conditions so favorable a decisive blow may be struck at some other point. The center of gravity of strategic combinations is not, in general, to be looked for in the position itself; for its value consists only in the tactical and operative possibilities it affords. To profit by these is the true solution of the problem. This is the proper point of view for the defensive to work from: for it is only in the rarest instances that the maintenance of a position for its own sake is of any decisive value in the ultimate result."

Fortifications increase not only the advantages of a frontal defence, but also its disadvantages. In the first place intrenchments are misleading by drawing attention to the value of shelter rather than to offensive power; they also make every change of front and transition to the offensive practically impossible, since both involve the abandonment of the protecting works on which reliance had been placed for defence. Fortified positions have a decidedly attractive power for troops but weaken the initiative in the command.

The opinions of Bernhardi as to the worth or non-worth of fortified positions, and of fortresses as such, have under the peculiar

conditions affecting us of Switzerland their especial importance. They show in the first place that we should never in such works be tied down by a fashion, nor be disposed to slavishly imitate any particular system, nor dare we see or expect to find in them our only dependence. On the other hand, they show that a defensive policy in wartime—and that must be principally the character of the part assumed by neutral states such as ours—will derive great advantages from the employment of such constructions and appliances: provided, that they come up to the standard in armament and technical equipment, and that they be properly manned by garrisons, whose elements are intensively instructed and prepared, so as to display in any emergency efficiency to the highest degree: for here also all half measures would be disastrous.

FORTIFICATIONS AS DEPENDENT UPON ADVANCES IN HUMAN KNOWLEDGE.

By

Capt. C. T. Sacket,
Engineers, U. S. A.

The study of history shows that improvements in weapons and war machines, causing modifications in the methods of attack and defense, have followed step by step the advances made in human knowledge, especially those in branches having to do with the composition of materials and the utilization of nature's forces.

That advance in fortifications depends on human knowledge is amply illustrated; in unenlightened districts, such as in certain parts of Africa, where no advance in civilization has improved the weapons, the same works of defense are employed to-day as in the time of Alexander.

Fortification is the military art of strengthening positions against attack. The earlier types were maintained for command and as an obstacle; the more recent must give satisfactory protection as well as concealment. Any means tending to that end, whether moral or physical, may rightfully be classed as fortification.

Field fortification is only the application of common sense to make more effective your own forces and to decrease the efficiency of those of the enemy in actual combat. It means a saving in man power. On the side of the defense it enables a numerically inferior force to resist a superior one. This allows of a thinning out of the fighting line at one point to rush troops to a more threatened point. Again, in the attack, fortifications or intrenchments allow this same thinning of troops at some point to obtain concentration for the attack at another.

The underlying principles never change and these comprise the measures for observation, cover, concealment, communication and obstruction. Too often only the development of the idea is seen and the principle underlying that development is not appreciated. Thus, though in the field, we may never see a trench constructed

exactly as laid down in the different manuals, yet as constructed it really is the typical form only modified to suit the site and available materials. Situations develop instantaneously and must be met in the same manner. No exact solution will suit all cases, but the same general principles may be applied throughout.

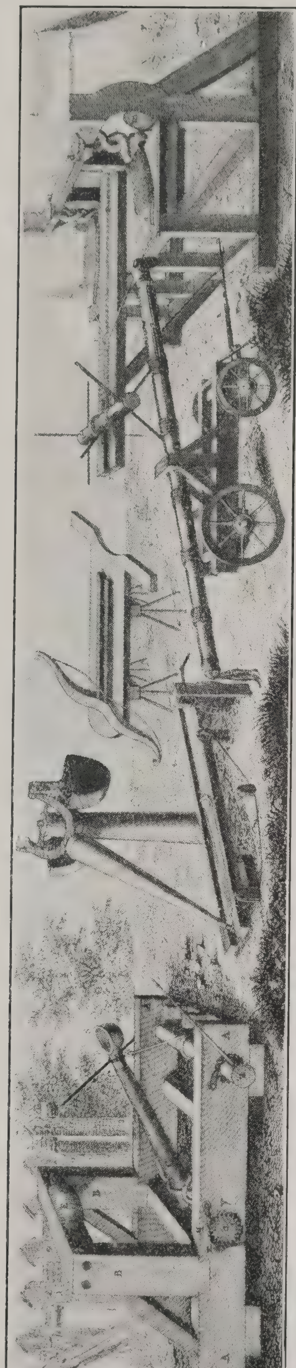
Coincident with, and depending upon, the range and power of the weapons in use, we find certain definite changes in methods of attack, met by necessary changes in defensive works both in plan and in construction.

FROM "ICONOGRAPHIC ENCYCLOPEDIA," D. APPLETON AND CO. BY PERMISSION.

Battle with spears, swords and clubs.

In earliest times, man fought man, on foot, unprotected and in the open. In those days superiority was had by morale, numbers and surprise rather than by superiority of weapons. So long as there were no long range missiles, no cover was needed until the enemy was actually encountered. The fortifications of that day were more of the nature of obstacles.

The first weapons were used in close fighting where a decision was gained through physical strength or agility. Swords, swinging clubs and spears forced the contenders farther apart. A pro-



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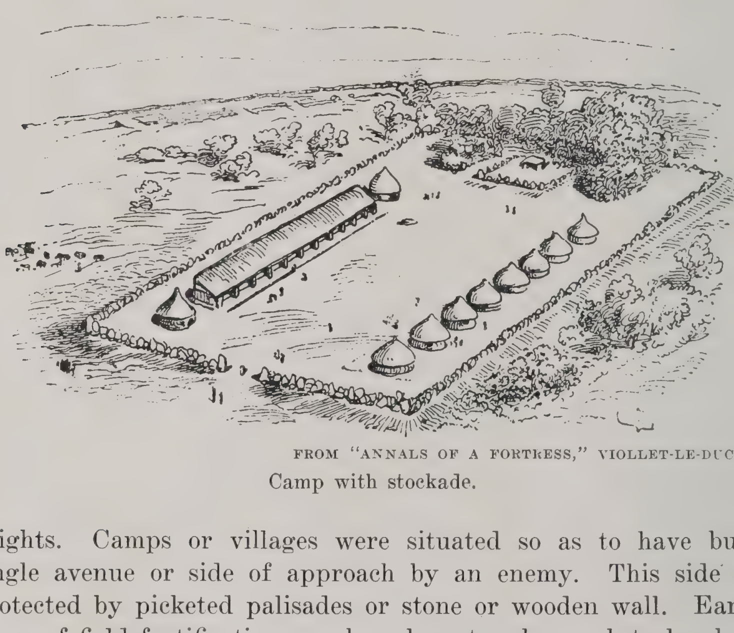
Various forms of balistæ, catapults and cross-bows.

tection was developed in skin shields. With a knowledge of the metals, especially tin and copper, came the metal shields and plate armor while missile knives, darts and hurling spears gave a still greater distance between opponents. In conflict, advantage was taken of natural cover such as trees, rocks and mounds of earth.

As men began to operate in groups, measures for the defense of their temporary or permanent abiding places developed. The first was probably a choice in location of camp site so as to provide against surprise. The early cliff dwellers so located their homes that access to their community was had by difficult paths, often requiring the use of scaling ladders. An approaching enemy could be showered with rocks and other missiles from the superior

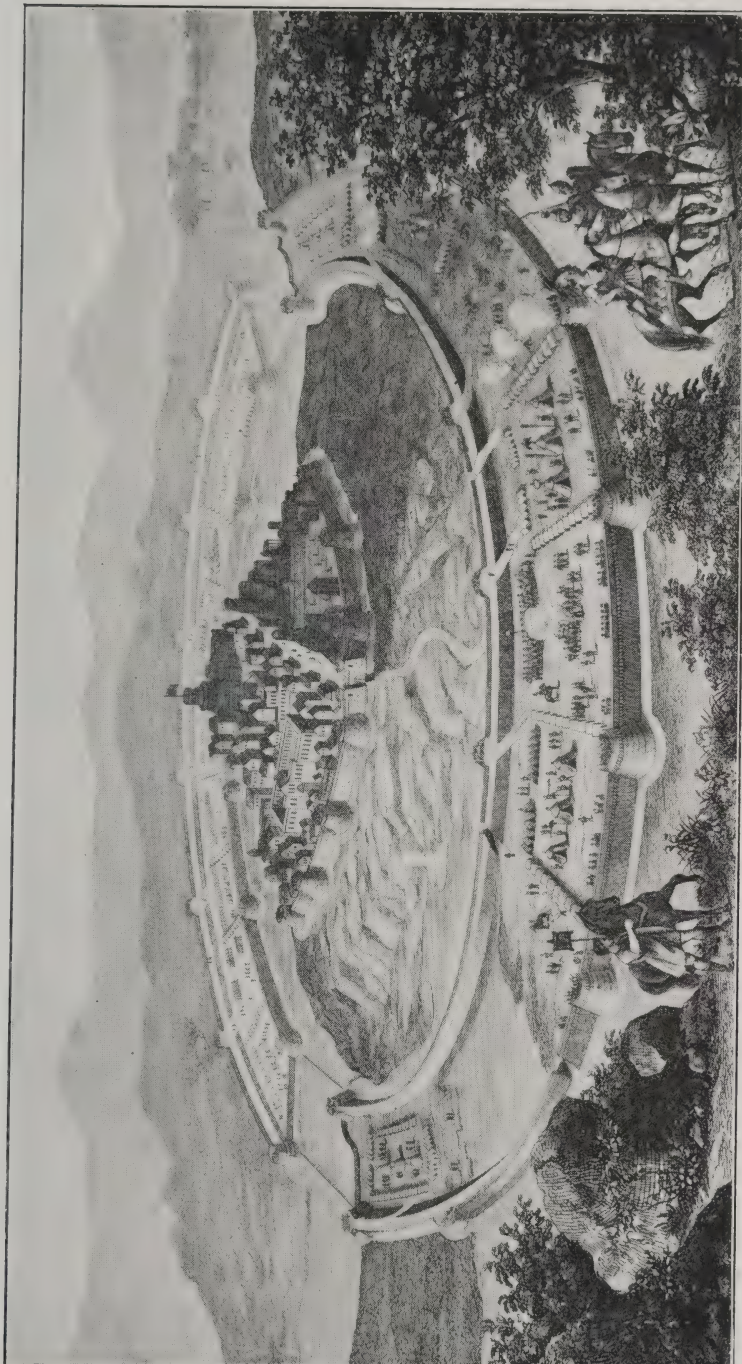


FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.
Camp with stockade.

heights. Camps or villages were situated so as to have but a single avenue or side of approach by an enemy. This side was protected by picketed palisades or stone or wooden wall. Earlier types of field fortifications, such as breastworks or obstacles, being on top of the ground, obviated the caring for drainage.

When the hunting people added to their pursuits the tilling of the soil and the domestication of animals they gradually moved to the lower lands and set up camps in the fertile valleys along the streams. A means of defense on all fronts then became necessary. Some sort of stockade was built or barriers of earth and wood thrown up around the camp.

The development of balistæ, catapults, and cross bows which propelled missiles by mechanial means rather than human



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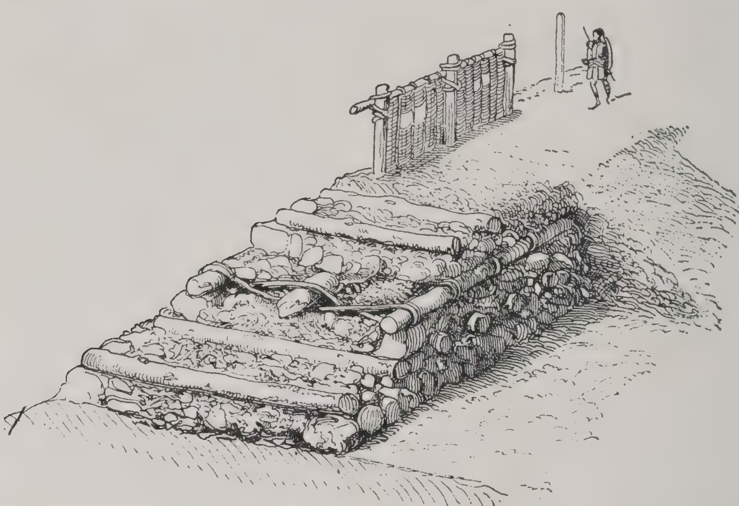
Series of circular fortifications.

strength again forced the contenders a greater distance apart. (See p. 695.) Sufficient distance was obtained to permit to the attackers a concentrating fire. To combat this concentrated fire, the defensive often assumed a rectangular shape. This shape gave a dead space at the corners which was reduced by the construction of towers at these points. The distance between these towers, or, in other words, the length of the straight wall or curtain, was gaged by the range of the weapons used as limiting the flanking fire, at this time being that of the bow and arrow. The height of command and observation from these towers gave the besieged an advantage besides permitting them to oppose the attackers with an equal length



FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.

Section of rampart with terrace walk and inclines.

of front owing to the several tiers or floors in construction of towers. Some of the best examples of towers date back to the time of Nineveh, about 2,000 years B. C.

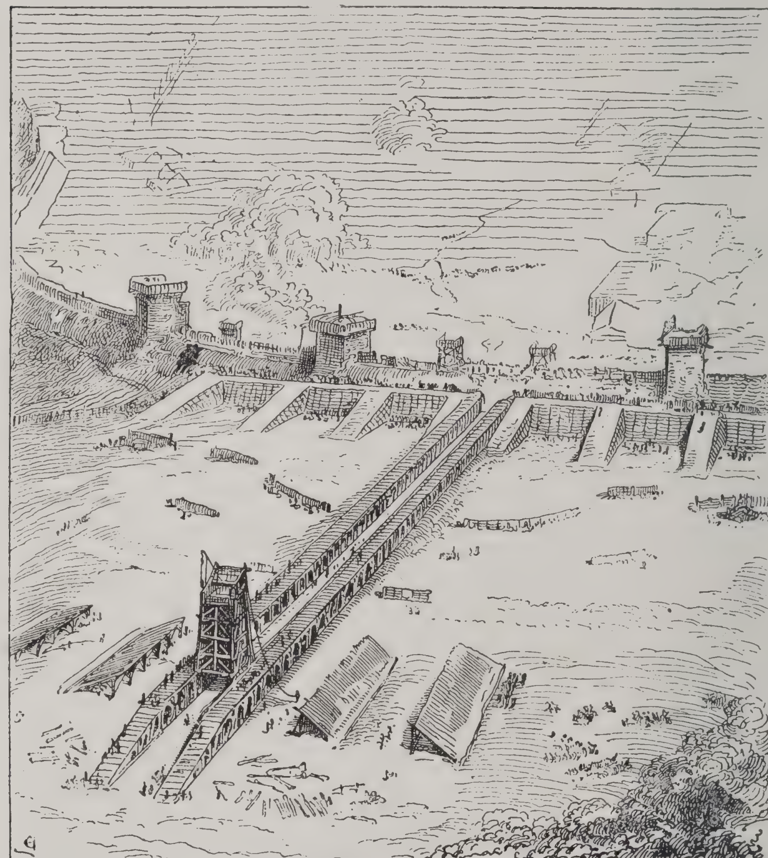
Missile engines were used by the Philistines against Jerusalem eight hundred years before Christ. Rams and movable towers are recorded as used at the sieges of Tyre and Jerusalem by Nebuchadnezzar nearly six hundred years before Christ.

In the 5th Century, B. C., siege craft was initiated by the Greeks who originated and systematized many methods relating thereto. But its greatest perfection was had by the Romans under Cæsar and in the early days of the Empire. Practically little or no further advance was made until the advent of the use of gunpowder.

FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.

Attackers advancing under shield.

During the time of Cæsar the thorn or brush hedge was strengthened by, and in many cases replaced with, banks of earth. This was particularly true of many of the German towns. These earthen banks were supplemented with tree trunks and stones properly arranged to strengthen the wall and at the same time to be



FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.
Movable wooden tower.

themselves protected from fire by the earth covering. (See p. 698.) The borrow pit for the earth for the parapets was utilized as a ditch, increasing the obstacle presented by the wall. The defense being on a closed perimeter permitted to the assailant a more prolonged front and a concentration of fire, but with the restricted range of weapons this was more theoretical than practical in its application.

Up to the Christian Era, the predominating permanent fortification was a wall with towers, usually circular, surrounded by a ditch or moat. These systems of walls and towers were often doubled and even trebled, one inside of the other. (See p. 697.)

To prevent the attackers advancing behind shields or curtains

FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.

A night sortie.

to the wooden walls and towers and breaching or setting fire to them, machicolation or overhanging parapets were used. (See p. 699.) The floors of these overhanging structures had holes in them through which stones, burning oil and other missiles could be thrown upon the enemy. To guard against still further destruction by fire, earth and masonry gradually replaced the wooden structures.

As catapults and other engines of war developed, walls and towers were greatly strengthened to withstand the projectiles and their structure was all of masonry. When the fronts to be covered became long, the number of towers was so increased that sufficient flank defense could always be provided. The earliest form of attack was an escalade by ladders or bundles of brush piled in the ditch. Danger from this source was soon obviated by increasing the height of wall. The ditches became broader and deeper, and

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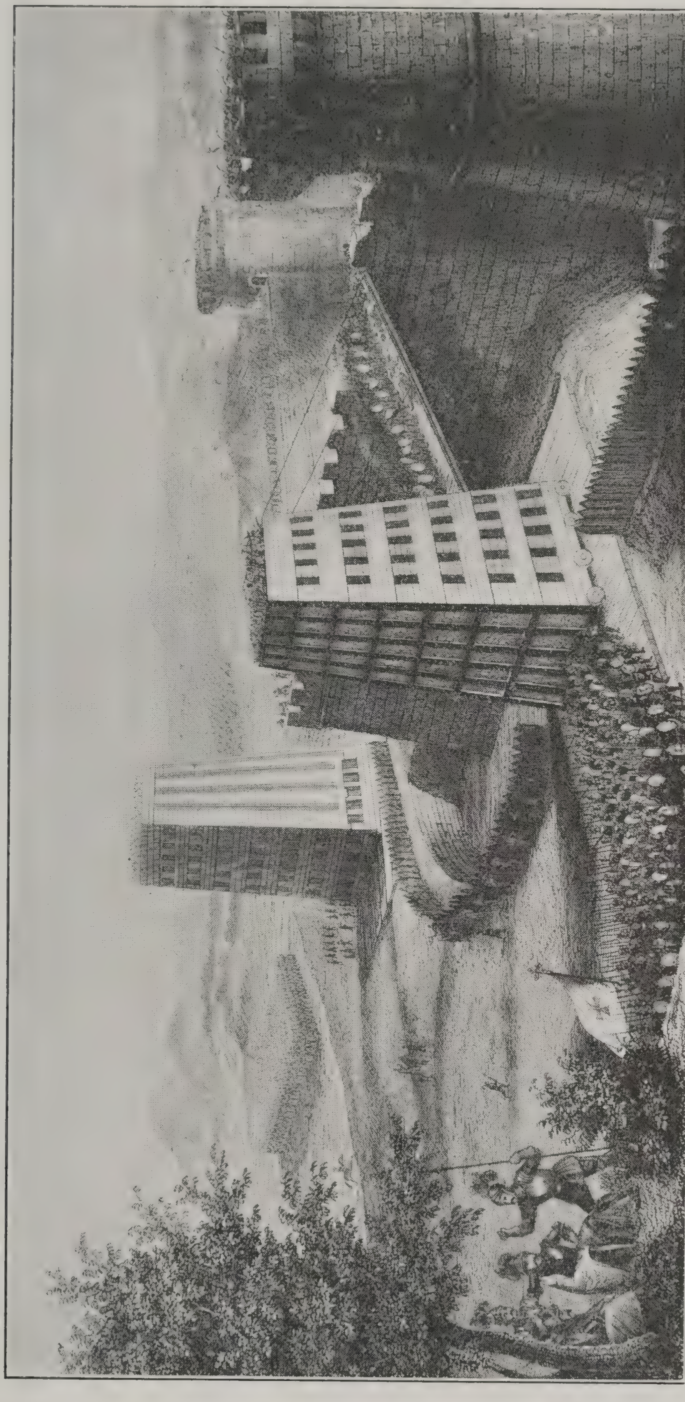
An eleventh century castle.

when possible they were flooded, forming moats, which had to be drained or filled before the walls could be reached and breached by the weapons of the day. Heavy walls were even undermined, and the wooden roof props burned for the purpose of throwing down the wall and breaching the defenses. The besiegers made use of similarly built but movable towers. (See p. 700.) The almost unlimited labor available during these times made possible the building of such structures as just noted. This work, such as the movable towers, in plain sight of the besieged led to surprise and night sorties and attacks to disrupt the work as much as possible. (See p. 701.)



FROM "ICONOGRAPHIC ENCYCLOPEDIA," D. APPLETON AND CO. BY PERMISSION.

Movable towers with bridges.

As the weakest part of the wall was at the greatest range from the flanking fire of the towers this had to be strengthened, which led to the construction of outworks at these points. These outworks were also surrounded by a deep ditch. So long as the fortified position remained comparatively small, the works assumed a geometrical outline with the towers at the salient angles, permitting the flank and cross fire so necessary to a successful defense.

During the dark ages no new ideas of fortifications or attack were advanced. Knowledge of siegecraft was almost lost. It was

FROM "ANNALS OF A FORTRESS," VIOLLET-LE-DUC.
Semi-circular advanced wall or out-works.

not until the eleventh century that siegecraft was revived and even then it was along old lines. Defensive works were superior to the means available for their destruction. This made them self-contained, isolated and independent. Citadels and castles resulted from this independence. This type of structure was of masonry with the necessary outbuildings and grounds surrounded by high masonry walls, towered, and surrounded with moat or ditch. (See p. 702.)

In the twelfth century the advantage of diverging fire was recognized and fortification walls were waved to obtain this result. Counter mining was introduced for the first time.

During the thirteenth century, the size and height of the castles greatly increased. The stone engines for attack were also enlarged. Barrels of burning pitch and oil were emptied on the enemy and attempts were often made to breed pestilence among them. The most effective means of attack was mining but the attack still remained inferior to the defense. Unlike the Romans who used the surer methods of mining and besieging, the people of this century lacked patience. Their choice was personal combat and the movable towers with bridges gave access to the top of the walls and permitted this. (See p. 703.) To offset this style of attack, the area

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Bastioned system of fortification.

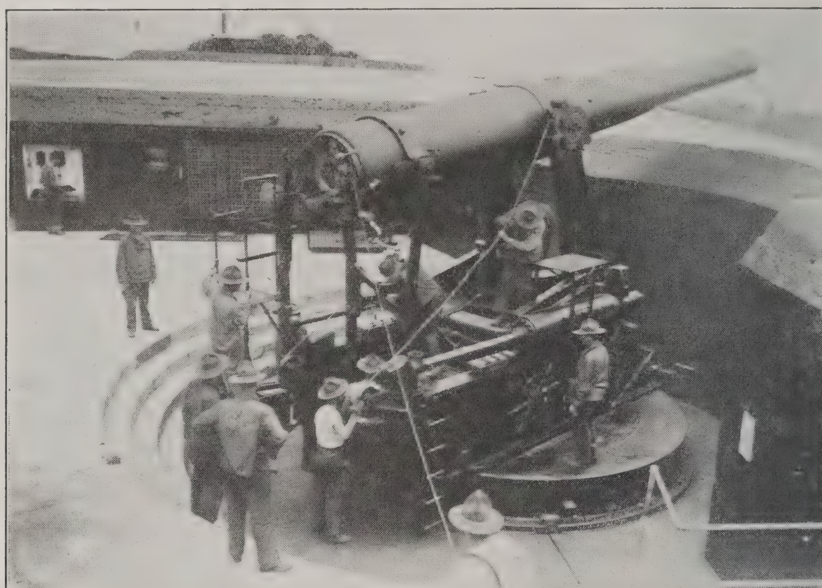
of defense was enlarged much more than heretofore. Flanking towers, curtains and complicated entrances were used to guard against surprise attacks.

The introduction of gunpowder wrought many changes. The first cannon were very light and produced little effect on the fortifications. At this time they were used chiefly in the defense. For a couple of hundred years gradual changes were made in the defense to meet new situations, but it was not until iron cannon balls were used in France in the fifteenth century that the defense of fortified castles was greatly weakened. The high walls were particularly vulnerable to gun fire yet the owners were slow to adopt the low parapet construction.

With the invasion of Italy in 1494 by Charles VIII the uselessness of old defenses against fire from cannon was quickly

proved. And to the Italian engineers as a body may be given a major part of the credit for improvements in these defenses. They greatly enlarged the towers and provided various curtains and casemates for them.

During the sixteenth century a change in construction was necessitated to make the walls less vulnerable to new weapons. The first change was the use of outworks or an advanced wall usually semi-circular in plan and built of earth and timber. (See p. 704.) It was used as a shield for the gateways and gave ad-



10-inch rifle.

vanced posts for artillery, permitting a flanking fire. It was also used as a screen for the walls themselves in which various other changes in construction were made such as decreased light, concealment, increased thickness, etc.

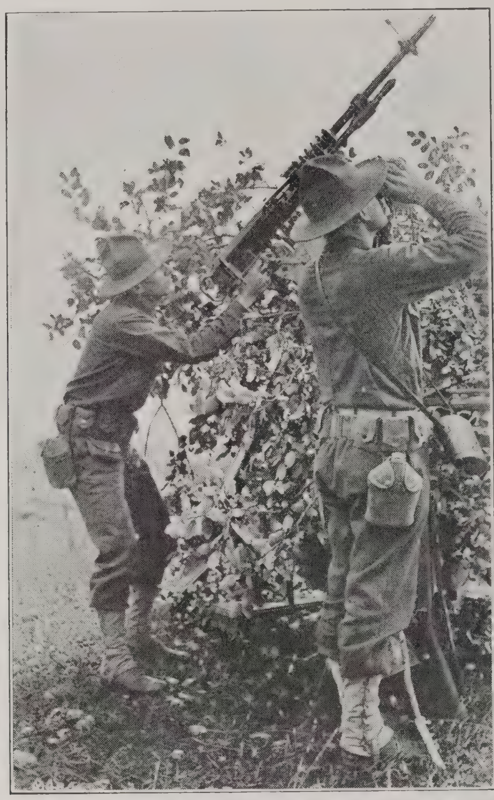
The bastioned system of fortification was most highly developed in the seventeenth century. (See p. 705.) It removed the burden of flank defense from the outworks. From this time on, considerable study was made of the theory of defense as well as its practical application which resulted in various changes in the traces of fortifications and led up to the polygonal trace of the eighteenth century.

Disappearing gun resting over emplacement.

Four 12-inch mortars in action.

The Germans, Austrians, Bavarians and French used the intrenched city or camp during the early part of the nineteenth century. To this defense was soon added the system of detached forts.

The year 1885 begins the era of modern fortification embodying high angle gun fire, concrete cupolas and shelter guns.



Machine gun mounted for use against air craft.

The cities grew to such an extent that continuous wall fortification was abandoned and the occupation of a line of "strong points," connected by a curtain of trenches, resulted. The distance between these points was governed by the range of the guns, each point supporting, and supported by, the adjacent fortified points on either side. They were so located that the enemy could make no advance toward his objective without first reducing them,

detours being fully provided against. Heavy guns are not mounted in these points, for as soon as discovered a concentrated fire would silence them. They are concealed on movable mounts behind the lines and their positions changed as soon as discovered by an enemy. Many improvements have resulted in great gun mobility which has greatly developed field fortifications. The 3-inch gun produces little effect on properly constructed trenches but guns from 6-inch up can hammer them to pieces.

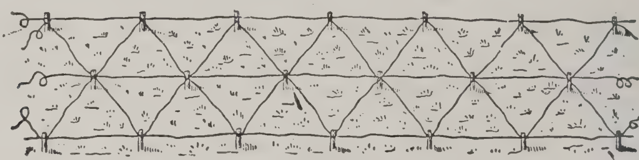
Machine gun in operation.

As projectile range increases and cities assume magnificent proportions, their defense occupies many miles of line requiring a large force to man them. As the transportation facilities permitted the quick gathering or mobilization of large armies, so the developments in wireless, telephones, telegraphs and aircraft allowed of their control as a unit and resulted in large tactical movements.

The range of big guns is limited only by mobility and traverse. From the time of Napoleon to the present day, the range has increased from a thousand yards to some sixty thousand, as in the case

of the big German guns outside of Paris. The chemists improved our powders and explosives. The metallurgists then solved the problems of guns to use these explosives; and so it goes—a constant interlocking and dependency on the sciences. As the knowledge of metallurgy increases, there is an advance in the size and range of guns, followed by a corresponding advance in the resisting measures of defense. (See pp. 706, 707.)

Improvements in weapons consist not only in greater range, but also in rapidity of fire as accomplished by breech loading and repeating small arms. Automatic rifles, pistols and machine guns have greatly increased rapidity of fire in addition to extreme portability and quickness in setting up and opening fire in a change of position with these weapons. (See pp. 708, 709.) The use of smokeless powder and indirect fire of heavy guns placed a still heavier burden on the defense.



Wire entanglement.

Increased intensity, accuracy and range of fire forced added deployment and a more extended front for both attack and defense. Extended order has been used ever since our early Indian fighting on the American continent. It has been developed and improved upon in the Revolutionary, Civil, Spanish-American, Boer, and Russo-Japanese Wars and right up through the years to the present time. In the present conflict use has been made of every form of wire entanglement and other obstacles. Many varied kinds of traps and infernal devices have been utilized. Even if a direct loss of life does not result, the delay under fire caused thereby indirectly makes a considerable loss.

Trench fighting is not new; it has long been used in siege operations; its first extensive use in field operations was during the Civil War by both northern and southern troops. Since then trenches have been greatly improved by the Continental Armies. Entrenching has become almost automatic when troops are halted, especially in an advance. The majority of trenches are executed in the face of the enemy. As a consequence they begin with the in-

dividual pit and are very irregular when connected up. Most trenches now are sufficiently deep to guard against back blasts from shells; if too narrow they tend to cave and prevent travel therein. The first line trenches are held lightly and the defense is in the counter-attack, quickly organized and hurled against the enemy.

To localize the effect of bursting shells entrenchments are traversed.. (See p. 712.) Lateral defense is greatly aided by the traverses. To meet this issue, use is made of hand grenades, with a

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Traverse.

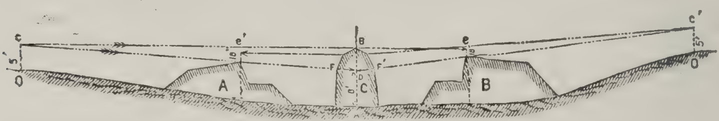
range up to about 50 yards, by both the attackers and defense. Rifle grenades increase this distance to 300 yards and are also used extensively in assaults.

Concealment, whether of obstacles, fortifications, guns or troop movement, has come to be a factor. Every advantage is taken of the physical configuration of the ground itself; of grass, weeds, brush, etc.; head and overhead cover and dummy trenches to mislead the enemy. Especially important is concealment from aircraft which are used extensively in directing gun fire. Conceal-

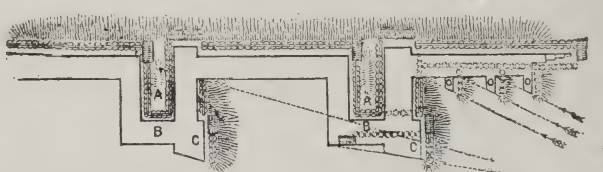
ment, whether from troops or aircraft, has become a branch for the specialist and troops are organized for this purpose. Range of artillery admitting of indirect fire in itself screens the guns from the front, but they must also be hidden from aeroplanes.

On the seas, the size and number of vessels have greatly increased together with their armament and protective armor.

The common and earlier types of seacoast fortification were the masonry, vertical walled forts with two or three tiers of guns and barbette top. (See p. 713.) Such an arrangement again equalized the concentrated fire from an extended front. During the days of wooden vessels, masonry was more substantial than the vessels; and though susceptible of destruction by guns from the vessels,



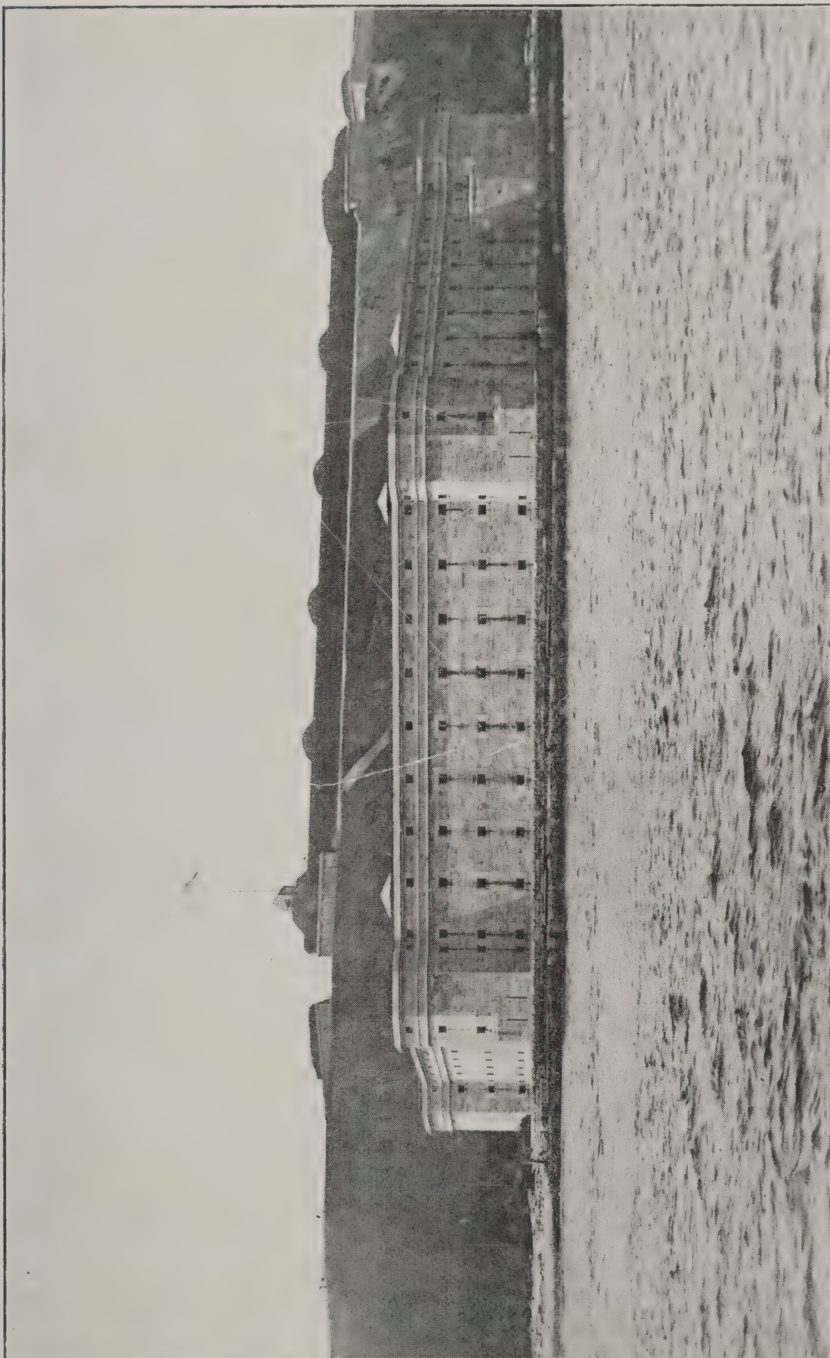
Section of parapets A, B, and traverse C to cover from fire from o, o′.



Plan of trench showing traverse.

the vessels in coming within or to that destructive range were themselves even more liable to destruction from the guns on land.

It was not until the beginning of the Civil War that the improvements in heavy guns increased their range and accuracy enough to permit breaches in masonry walls to be made from any great distance, so that rifled cannon, mounted after a landing had been effected, could be used to demolish seacoast defences from comparatively remote land points. No vessel in itself has ever been able to accomplish such a result, irrespective of perfection of armament; on the other hand no masonry fortification has been able to withstand the systematic reduction possible from land batteries. This has led to the abolition in land fortification of all masonry exposed to view, and the substitution for it of earth with a natural slope. In the latter half of the nineteenth century, the accuracy of heavy gun fire was increased to a degree which made it possible to hit a target when its position was known. Then the fortification



Fort Wadsworth, New York Harbor.

was hidden from view, and the method of indirect fire was developed. This compelled the abolition for works of fortification of all uncovered masonry. The scarp from the level of the bottom of the ditch was made of earth. Since by this time the destructive power of shells has also increased greatly, the exterior slope was made much flatter than the natural slope, in order to decrease the destructive effect of shell craters.

Developments in section, plan and materials of construction of fortifications up to the present day, may be briefly summarized as follows:

> Obstacles rather than fortifications proper;
> Use of natural cover such as rocks and mounds of earth;
> Straight line wooden palisades and walls;
> Inclosing wooden walls of rectangular plan;
> Use of towers and bastions on these walls;
> Change in plan to hexagon or similar geometrical design;
> Machicolation;
> Use of outworks;
> A double line of defense with outer walls and inner fortress;
> Replacement of wood with masonry;
> Abandonment of exposed masonry in fortifications;
> Increase in lines of defense both in the area covered and in the number of successive parallel lines of defense.

Recent advances in the art of war have been along industrial lines. Rather than new inventions, have come new applications of old ideas. The steel helmet, obstructions and bayonet fighting have come down through the centuries. Gas and liquid-fire can hardly be called innovations, but their use has been greatly amplified. For observation, scouting and communication, we have motorcycles, aeroplanes and captive balloons; among offensive weapons we have the submarines, armored tanks and fighting planes; even the heaviest guns are capable of comparatively quick transfer; food is prepared close to the front lines in portable kitchens; men and materials are handled by auto trucks and industrial railways; and the wounded are returned to dressing stations and hospitals by the motor ambulance. Smoke, in some cases a disadvantage, obviated by the use of smokeless powder, is now utilized with success as a "screen" in various operations on land and water. The use of airships in warfare is the one really new development.

Military preparation requires a constant outlay which must be considered as insurance, for the losses through defeat are more burdensome than the cost of measures that would prevent that defeat.

All defense works are a means of economy of troops. Men with only their heads above field trenches stand less chance of being hit than when standing up fighting in the open. Field fortifications lightly manned, may stay an army to cover a retreat or enable reinforcements to be brought up. Advance knowledge is always to be had of permanent works, permitting study and plans of attack. Such attacks develop into lengthly siege operations in which mining and sapping play an important part. But whether temporary or permanent use is made of them, they are but a means to an end. If they do not permit the gathering of that mobile reserve which is to deliver the final blow, whether on land or sea, they have failed of their purpose. Of a permanent character they are generally built at selected sites, during peace times. Too often a false security is placed in them and the all important reserve is not mobilized; a passive defense is developed which can never lead to a decision. Definite success comes only to him who is willing and able to eject an enemy from the physical space he occupies and to hold that space until he ceases to be an enemy.

DEVELOPMENT OF GUN MANUFACTURE[1]

By

Lieut. W. H. W. Skerrett[2]

Before the beginning of the Great War, the average civilian had but a vague idea of the part which artillery plays in the modern battle. The infantryman with rifle or revolver was the most familiar figure in army life; he and the sabered cavalryman typified the fighting man and the spirit of war. It was not until September, 1914, after Liége and Namur had fallen in rapid succession and giant 42-cm. howitzers of the Germans were being turned against the thin line of British troops in France, that the importance of artillery dawned upon the public.

As we look back upon those terrible days which preceded the battle of the Marne and the Aisne, we realize how grateful civilization must be that the English and French had foreseen the rôle which field artillery would play in a modern battle. On those September days when the fate of civilization hung trembling in the balance, the waves of massed Germans were broken and flung back from Paris by thin lines of men and of guns. Only a handful of British troops, compared with the armies now in the field, by sheer grit held the Hun at bay until the French could gather their men for the blow which stopped the German advance and made the enemy dig in on the Marne, and later drove him out of his trenches and made him retreat. Most of us then began to ask for information about guns and ammunition.

We have heard of drum fire, barrage, and a dozen other features of artillery work, we have read of gun fire from the Flanders battle front being audible across the English Channel at Dover and other coast towns, of artillery preparation so complete that the craters formed by the bursting shells overlapped. An instrument which can project a mass of explosives and metal weighing a ton at the rate of 2,200 feet per second, with such accuracy that six shells form

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[1]Reprinted, by permission, from *The Journal of the Society of Automotive Engineers*, August, 1918.

[2]Inspector of Ordnance, Ordnance Reserve Corps, U. S. A.

overlapping craters at a range of 17 miles, is an engineering creation which demands our attention. Another type is able to discharge 30 shells per minute, each one aimed and timed to do the greatest damage to hostile troops.

A series of these can project a wall of leaden bullets and flying fragments of steel of such density that nothing can live through it if exposed to its direct force—a spray of steel which covers the ground beneath it with metal sufficient to disable anyone who tries to advance through it, yet permitting those who are depending on it for defense to walk behind it with a sense of security knowing that its accuracy is 99.9 per cent perfect, even though the gunners directing the fire are unable to see the object upon which they fire.

When one realizes that some 600 guns of all calibres have been concentrated upon a strip of territory less than three miles long and about two miles wide, some idea of the intensity of fire resulting may be obtained. On a front of 3½ miles at Verdun the Germans had approximately 150 batteries of all sizes, while on a front of 2½ miles the French had about 120 batteries of guns of all sizes. During the height of the storm for the possession of some of the key fortresses in the line as many as 1,000,000 shells per day were fired, the number being about equally divided between the French and the Germans.

EARLY TYPES OF CANNON

The original gun bears as little resemblance to the pieces used today as the original "horseless carriage," with its sleigh front and handle-bar steering arrangement, resembles the modern sedan with all its improvements and refinements of body and power plant.

The first guns of which we can find record appear to have been made in Ghent in 1314, at which time an entry was made in the town clerk's records of a "gun with powder" being sent to England. According to pictures made about that time, the gun was vase-shaped (the Italian name for it was "vasi") and was used for shooting darts. Powder was placed in the bowl of the vase and an iron dart was rammed firmly into the neck. The neck was made gas-tight by means of a tampon wound around the shaft. A touch hole in the side was used. The range was a few hundred yards and the damage done by the dart was considerable, although the noise of the explosion seems to have been more effective than the missile, for a historian of that time tells us that "the thunder struck terror to men and horses so that they dared not fight"—and, as an afterthought, "some there were who suffered wounds."

Most of us believe that guns were first used in 1346 at the Battle of Crecy, for it was there that the English used their three guns with great success against foot soldiers and mounted men. This is perhaps the first record of guns in a field battle, and so we may say that field artillery was born at Crecy, although fifteen years before (1331) the Germans had used siege guns at Clividale in Italy. The projectiles used were rounded stones smaller in diameter than the bore of the guns. Pressure was obtained by wadding the charge with turf. The guns at Crecy used iron slugs, which were very effective against horses.

Little development occurred in field artillery, however, during the next hundred years, although siege guns of large size appear to have been used. In 1446 the hand gun or musket made its appearance and became the deciding factor in battles from that date. Owing to their lack of mobility, guns were not adapted for field work and were used only during sieges, when the time necessary for transporting artillery from one point to another permitted them to be brought into position; the pieces were clumsy and heavy and the wagons then in vogue were also cumbersome. With the increasing superiority of musket fire, artillery quickly fell into disuse, and not until 1630 did it again advance to a position of importance.

FIRST USE OF MOBILE ARTILLERY

In 1631 Gustavus Adolphus, King of Sweden, made use of mobile artillery in sweeping over most of northern Europe, especially that part now occupied by the German Empire, and, with less than fifty guns, drove his opponents into their fortified towns where he besieged and defeated them. His greatest enemy, Tilly, with a much superior force, was unable to bring up his heavy guns (24 pounders, which correspond to our 4-inch pieces) and was routed time and again by Gustavus' cast-iron 4 pounders, which were able to pour a heavy fire upon his flanks.

Gustavus was the first to classify and set limits upon heavy and light artillery. He classed as light or mobile artillery all guns up to and including the 12 pounders (a light 3-inch), but recommended an 8 pounder or lighter for extensive campaigning. In fact, in 1632, when he finally defeated Tilly, he was able to cross the Danube in face of a much superior force by reason of the mobility of his 4 pounders, of which he then possessed about sixty.

During the seventeenth century the organization of the artillery was very loose. Apparently the only persons in the military service

were the gunners or "masters of ordnance" who supervised the firing of the pieces, laid the guns and took the place of officers of a modern battery. Their assistants were hired men, who usually deserted or abandoned the guns at the first signs of danger. These men were released as soon as the need of their services disappeared, and, very naturally, the training had to be repeated each time a battery went into the field.

With the introduction of the flint-lock musket, the use of artillery became limited to siege operations, where sufficient time for organizing and equipping a siege train was allowed. Therefore, large calibre guns were constructed with bores of 12, 14 and 16 inches which threw stone or iron projectiles weighing as much as 700 to 800 pounds. Some great pieces of 20-inch bore were also constructed, but difficulties in mounting them arose and the engineers of the times were unable to find a solution.

Burning shells were introduced and a few explosive shells were used.

ADVENT OF BREECH-LOADING GUNS

Some early attempts were made to overcome the difficulties of muzzle-loading guns, and breech-loading pieces were unsuccessfully tried. These were failures for two main reasons: the necessary strength could not be obtained and the gases leaked through the joints. So hazardous, in fact, were these guns that they were abandoned, and it was not until 1845, when Major Cavalli, a Sardinian officer, introduced the sliding wedge type of breech block, that muzzle-loaders began to lose first place.

In this gun, which was also one of the first to be rifled, the chamber was sealed by a copper plug and an iron wedge was inserted through the body of the gun, which prevented the copper from being blown out.

Until 1739 all guns had been either cast or forged on a mandrel, and naturally the bore was rough and full of irregularities, which allowed the gases to leak around the projectile and reduced the power and range to an enormous extent. The range, at best, was only a few hundred yards, and the flight of the shell inaccurate. The wadding was very important, as upon it depended the pressure developed and therefore the velocity of the shell.

Powders, also, were an unknown quantity, some being much more powerful than others. We wonder that results could be obtained when so many variables were introduced.

With the advent of bored guns—Maritz, a Geneva gunmaker, in 1739, having bored the first from a solid bronze casting—the power and accuracy increased immensely. The shell was made to fit the bore closely and much higher velocities were attained. Aided by the explosive shell, artillery became a factor in battle against which musketry could not compete. The use of bombs and grapeshot against fortifications and troops greatly changed military tactics.

In the eighteenth century wheeled mounts were also introduced successfully, and artillery became mobile enough to accompany troops in the field, to maneuver ahead of them and to break up enemy formations before the infantry attack could be delivered.

ARTILLERY FIRST USED FOR DEFENSE

During the time of Frederick the Great, the use of artillery underwent a great change. During the early part of the eighteenth century the approved strategy consisted of driving the enemy's army back upon some fortified town by a series of cavalry and infantry attacks or battles, and then besieging the town until it surrendered owing to sickness or starvation. If necessary, heavy howitzers were brought up and the fortifications demolished by gunfire until the chances of carrying the place by assault were assured. Frederick the Great, about 1760, introduced the idea of using artillery as a terrible defensive weapon by luring the enemy into battle and then annihilating him by massed batteries using grapeshot. Thus by the end of the Seven Years' War his "wall of four hundred cannon" was known as the iron ring through which no army could break, and at Burkersdorf he sent a great battery of 50 howitzers into action against the fortifications, which were reduced in two days. Thus siege operations were reduced from months to days and artillery became more important as a deciding factor in battle.

Napoleon used artillery to break up both foot and cavalry charges in both frontal and flank attacks and always maneuvered to bring his artillery out in front of his troops so that the guns might open gaps in the enemy line, through which he could pour his troops. It was not until his opponents learned to follow his example that he was checked.

By the time of the Civil War, the position of artillery was changed again, for the long range musket or rifle had been introduced shortly before and the guns needed infantry support. Therefore the batteries were placed in the same line as the troops and the enemy had to advance into a concentrated rifle and artillery fire in

which his own guns could take little or no part due to fear of firing upon their fellow soldiers. The advent of the rifled gun and the explosive projectile made possible the use of batteries behind the lines out of sight of enemy observers, but due to the imperfections of the ammunition, the damage done was not in proportion to the increase of range. Time fuses became more accurate and shrapnel began to be introduced—the rifled gun increased in accuracy and the breech mechanisms improved.

GUN STRESSES

With the demand for greater range and accuracy, attention turned to increasing the strength of the pieces. It was recognized that a gun was subjected to two strains—one circumferentially, which tended to split the barrel longitudinally, and the second which

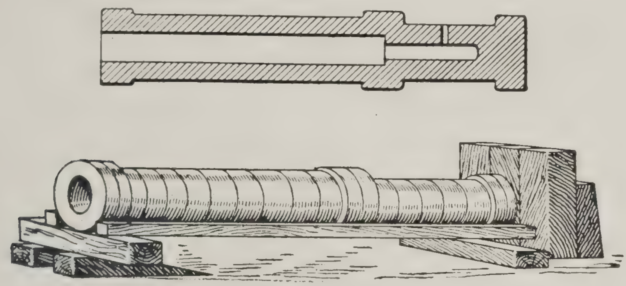


Fig. 1. Typical gun of the Fourteenth Century

acted to break the gun apart lengthwise by blowing off the breech or muzzle end. The circumferential stress is the most difficult to resist, for the strength of a simple gun, that is, a solid one-piece gun, soon reaches a limit of thickness beyond which additional metal gives practically no increase in strength to resist circumferential stress. In a simple gun, only extension of the metal occurs, and when it has reached its limit, rupture occurs. If a gun is built up upon a system of initial tensions a compression will result in the metal bore, which compression must be overcome before the extension of the metal can occur. Thus the strength of a simple gun is proportional to the *extension* that it can withstand before rupture, while a built-up gun is proportional to the *compression* plus the *extension*.

RIFLING OF GUNS

Lord Armstrong, in 1855, introduced the first built-up gun of this type and met with great success. Wire winding was introduced

at the same time and was also successful from the start. From 1850 to 1870 the main improvements were in breech mechanisms, rifling and ammunition. The importance of steady flight was recognized and the long tapered shell took the place of the round shot previously used. This shell was given rotation in various ways, the first plan being that of a twisted ellipse or hexagon. The Whitworth gun had a cross-section which was hexagonal and a twist of one turn in 25 calibers, and the shell was cast with a similar form, making a good mechanical fit in the bore. This gun and the Lancaster oval bore gave trouble by the projectile becoming wedged. Upon this occurring the gun would explode, so that they were abandoned in favor of the grooved rifling which was adapted to studs or lead and copper bands. The copper driving band is used at present. The band is slightly larger than the diameter of the gun, so that the soft copper is forced into the grooves, forming a gas-tight joint, and the twist causes the projectile to rotate, tending to steady its flight. The rifling is usually made with an increasing twist. In 1880 the metallic cartridge case was introduced.

NON-RECOILING CARRIAGE

In 1890 the non-recoiling carriages were used. Previous to this the gun and carriage as a whole recoiled after each shot and had to be realigned before firing again. Also, any attempt to limit its recoil had been made by increasing the weight of the mount. The constraining of recoil developed great stresses in the carriage and made heavy cumbersome mounts necessary. With the spring recoil and non-recoiling carriage, the gun was automatically brought into the firing position after each shot. This allowed the carriage to be aligned, and the alignment was held until firing in that position was discontinued. It made rapid fire possible and simplified breech mechanisms, and fixed ammunition in metallic cases further increased the rapidity with which the guns could be discharged.

ACCURACY OF SHRAPNEL FIRE

Time fuses were perfected and shrapnel became one of the most used types of projectile. It is now possible to lay a barrage of shrapnel fire that is accurate to 50 yards, a thing which was impossible until just before the beginning of the present century.

The power and velocities of guns were also increased until today we have a gun with a velocity of 4,000 feet per second which shoots more than 70 miles.

DEVELOPMENT OF EARLY GUNS

We will now consider the component parts of a simple gun and then trace the successive stages of development through which it has passed in the last few decades, for since 1850 the strides have been enormous.

Fig. 1 shows a simple gun such as was used in the fourteenth century. It consisted of a cast-iron barrel slightly larger than the

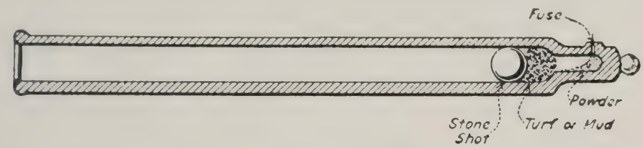


Fig. 2. Section of Early Gun

diameter of the shot which it expelled and a small powder chamber which was filled from the muzzle. The gun was held rigidly between two timbers and prevented from recoiling by stakes driven into the ground. It was elevated by means of wedges placed beneath the muzzle and had a range of a few hundred yards.

Fig. 2 shows a later development of the same type, which was the kind used for siege purposes during the fifteenth century. These guns often had a bore as great as 20 inches and fired a

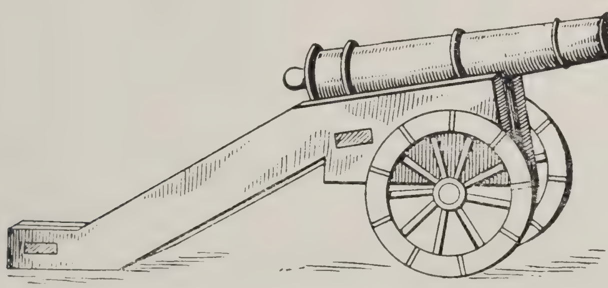


Fig. 3. Early Type of Wheeled Gun Mount

stone missile weighing 700 pounds a distance of 400 yards. The gun itself weighed 14,000 to 16,000 pounds without its mount and was not mobile. Often these guns were set permanently in emplacements and kept loaded at all times.

In Fig. 3 the elevation of the gun was changed by wedges driven between the intermediate transom and the breech end of the gun. This type was superseded by a gun which was mounted on a carriage

provided with an arc. A lug on the breech end slid in this arc and the angle of elevation was set by placing pins through holes in the arc and lug. This type was used until the end of the Napoleonic wars.

Fig. 4 shows a simple cast gun with sliding breech block. This was the first gun to use the breech-loading principle successful. The projectile was inserted through the breech and fitted into the rifling. The powder was next placed in the chamber and rammed home. A fuse was inserted in the touch hole and the breech closed by means of a copper plug. The wedge was then driven home, forcing the copper plug tightly against its seat so that it would not

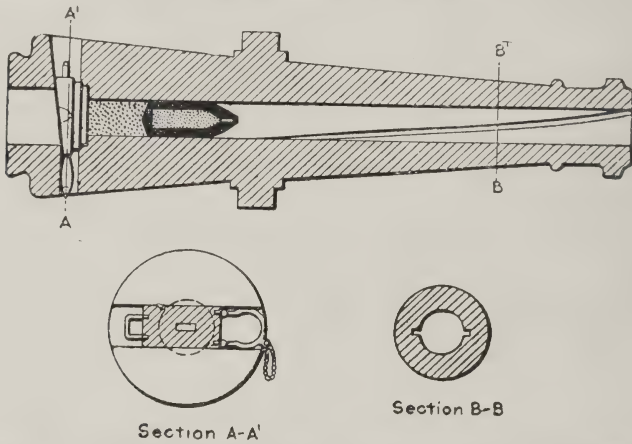


Fig. 4. First Gun Using Breech-Loading Principle Successfully

allow gas to escape. The force of the explosion merely tended to force the wedge backward and not to slide out of its seat.

Following these operations, fire was applied to the fuse sticking from the vent hole—which in turn ignited the powder in the chamber. This was converted into gas and, due to the pressure, the shell was driven forward; the rifling grooves hold two lugs which were cast on the exterior of the shell, causing it to rotate. This rotation was necessary, as otherwise the shell would tumble end over end and its range would be decreased.

BUILT-UP GUNS

Fig. 5 shows a built-up gun consisting of a tube *A* or inner cylinder with a jacket *B* shrunk over it. The tube is recessed at the breech end to form the powder chamber *G* and is closed by the

breech block *D*, which fits into the bushing *C* as shown. This bushing has an interrupted thread with three blank portions milled out. The breech block with a similar arrangement of threads and blanks is inserted and locked in position by being rotated through 45 degrees. The escape of the powder gases is prevented by the gas check pad *F*, which rests upon the bevel slope *J*. By the action of the gases in the powder chamber, the head *E* is forced back, compressing the gas check pad against its seat. The centering slope *H* enters the shell and the rifling *K* gives it the required rotation. The breech ring *L* is provided with a lug and hole by which the recoil mechanism

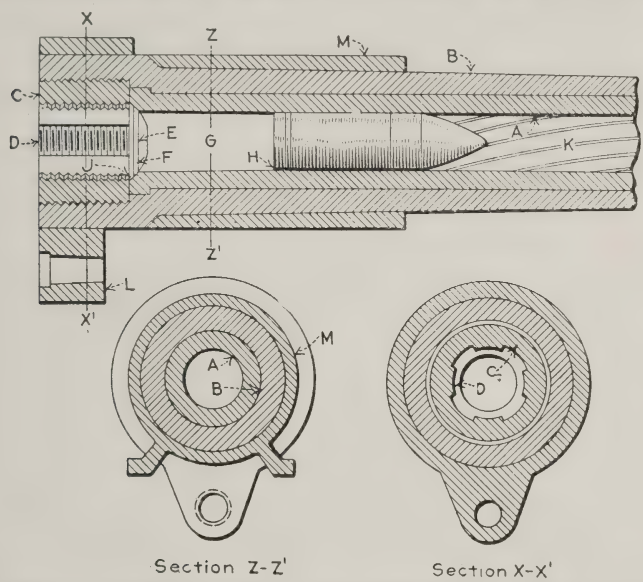


Fig. 5. Longitudinal and Cross Sections of a Built-Up Gun

is attached to the gun. The guide ring *M* carries the guides, which allow the gun to slide in the cradle while recoiling.

The jacket is a forged steel tube which is bored to a diameter slightly smaller than the exterior of the tube on which it is to be shrunk. Shoulders are counterbored so that the tube will not be driven out of the jacket while firing. Sometimes the jacket is threaded instead of being provided with shoulders, but this complicates the manufacture and shoulders are more universally used. The jacket is heated in an oil or electric furnace until it has expanded sufficiently to slip over the tube. When it has reached the required temperature it is removed from the furnace and placed over the tube. To ensure a contact at the breech shoulder

this end of the piece is cooled quickly by spraying with water, which causes it to contract and grip the tube at this point. The rest of the forging is now cooled slowly so that it will contract toward the breech end. When finished, the compression is about 50,000 pounds per square inch as a general average.

The breech end of the gun is next threaded so that the breech hoop or ring can be assembled. This hoop or ring carries the breech

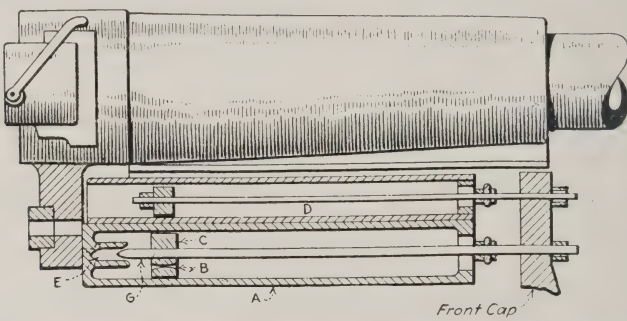


Fig. 6. Cross Section of Typical Recoil Mechanism or Recuperator

A—Oil cylinder. B—Orifice. C—Brake piston. D—Air cylinder. E—Counter recoil buffer. F—Counter recoil valve. G.—Buffer plunger on piston rod.

block. In cases where a plug is used, the breech hoop is provided with a bearing for the breech block carrier arm, and when the sliding wedge type of block is used the breech ring forms the seat for the block and the bearing for the arm and operating lever.

The guide rings are often omitted and the feet are shaped direct-

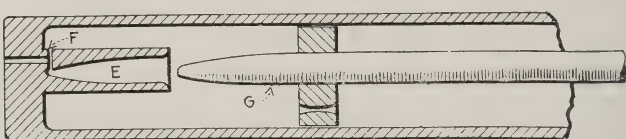


Fig. 7. Enlarged View of Counter Recoil Buffer

ly from the jacket. These feet slide in a groove cut in the cradle and guide the gun during recoil.

RECOILING DEVICES.

There are two main systems of recoil regulating devices: the spring and the hydraulic. In the spring type the energy of the gun is absorbed by the work done in extending a heavy coiled spring and the piece is returned to the firing position by means of the spring. A counter-recoil buffer is provided so that the gun will

not fly back violently after it has reached the limit of its recoil. This is usually some type of dash-pot.

In the hydraulic device the energy of the recoiling gun is converted into the work of forcing a liquid, usually oil or glycerine, through a small orifice or past a valve. The counter-recoil is effected by springs or compressed air, a buffer being provided as before to ease the shock of return. Fig. 6 shows the cross-section of a typical recoil mechanism. The cylinder *A* contains oil which is forced through the orifice *B* in the piston. This piston is attached to the frame of the carriage while the cylinders recoil with the gun. The cylinder *D* contains air under an initial pressure sufficient to maintain the gun in the firing position at the maximum elevation. Upon recoiling the air is further compressed, which also creates

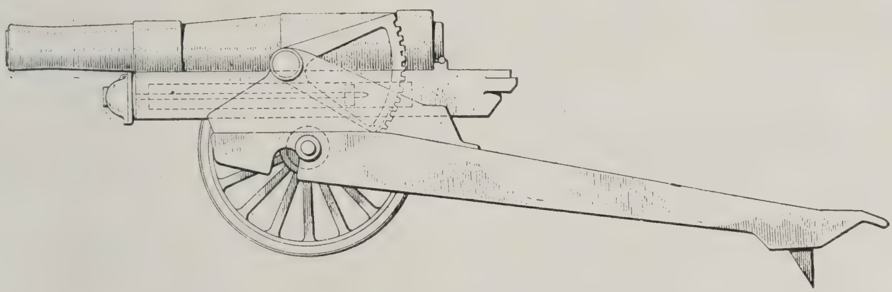


Fig. 8. Showing the Component Parts of a Recoil Type of Gun

resistance against which the gun must work during recoil. During counter-recoil the compressed air expends some of its energy in bringing the gun back to the firing position and an appreciable amount in forcing the liquid through the orifice in the piston *C*. A counter-recoil buffer is provided at *E*, Fig. 7, where the extension of the piston rod *G* enters a dashpot having a minute opening which is regulated by the valve *F*.

Fig. 8 shows a complete gun with gun proper, recoil device, cradle or sleigh, carriage and trail.

The recoil device is carried in the cradle, which can be elevated or depressed. The lateral traverse of the piece is obtained by the carriage, which is hinged directly to the trail. For deviations greater than those possible with the traversing gear on the carriage, the trail must be moved.

The trail is provided with a spade which prevents it from recoiling and steadies the piece during fire.

CALCULATION OF GUN STRESSES

The strength of a gun is obtained in two ways, first by shrinkage as before described and secondly by wire winding. By Lamé's formula for hollow cylinders the tangential unit-stress

$$S = r_1^2 \frac{R_1\left(1+\frac{r_2^2}{x^2}\right)}{(r_2^2 - r_1^2)}$$

where R_1 equals the interior pressure and r_1 and r_2 equal the interior and exterior radii of the cylinder and x is the distance from the axis of the cylinder to the point where the stress is being measured.

By solving this formula we find that the value of S is greatest at the inner radius and is equal to

$$S_1 = R_1 \frac{(r_2^2 + r_1^2)}{(r_2^2 - r_1^2)}$$

The use of this formula may be shown by giving the results of shrinking a hoop upon a tube so that a pressure of 5,000 pounds per square inch exists between them. Let the inside and outside diameter of the tube be 4 and 6 inches respectively, and let the interior pressure owing to powder gases be 25,000 pounds per square inch. By solution of Lamé's formula the resultant tangential unit-stress in the bore is found to be 47,000 pounds per square inch, as compared to 65,000 pounds per square inch, which would result if the tube were not hooped. If the same figures are used, except that the unit pressure caused by the hoop is increased to 10,000 pounds per square inch, the resultant tangential stress would be reduced to 29,000 pounds per square inch at the bore.

Wire winding tends to reduce the size of jacket or covering necessary to obtain the same initial unit pressure, for it has been shown by experiment that the pressure resulting from a series of unit pressures is the algebraic sum of the tangential stresses set up by each one individually.

Two shrinkages, however, should be noted—the absolute and the relative shrinkage. The absolute shrinkage is the difference between the exterior diameter of the tube and the interior diameter of the jacket. The relative shrinkage, on the other hand, is the absolute shrinkage divided by the radius of the contact surface.

The firing of the shell creates a pressure which tends to expand the inner tube. If the pressure is great enough it will break

off. If the tube or jacket were not shrunk on, the pressure would break the inner tube. The limit of stress would be the point at which the tube would break during firing. During the process of shrinking on the jacket the inner tube is reduced a certain amount; this compression of the tube adds to its strength. Before it can exert any strain on the tube itself, the force of the expanding gases must not only overcome the pressure that the jacket places upon the tube, but in addition the resistance of the metal in the tube. The stress imparted by the shrunk jacket, plus the strength of the metal itself, makes it possible to build high-power guns as we build them today.

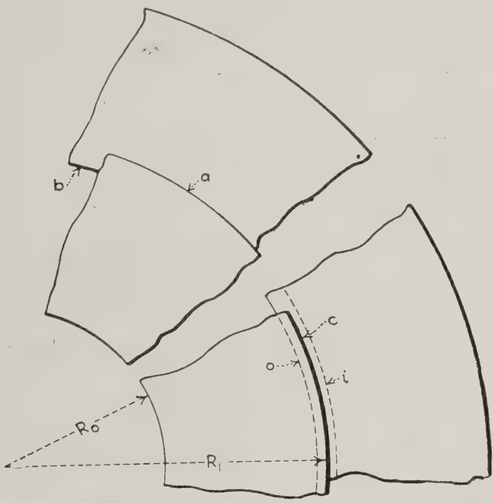


Fig. 9. Illustrating Absolute and Relative Shrinkage

Referring to Fig. 9, where *a b* is the absolute shrinkage and R_0 and R_1 the interior radius and the radius of the surface of contact, the relative shrinkage

$$\Phi = \frac{ab}{R_1} = \frac{oc + ci}{R_1}$$

The relative compression is C/R, which is the total compression per unit of radius. It is this value which governs the stress in the tube.

Most compressions and shrinkages are given as a certain amount per inch when worked from the design viewpoint, but for shop use the total shrinkage is given. Thus, taking a tube of 6-inch diameter with 0.001 inch per inch shrinkage, the drawings would show a total shrinkage dimension of 6.006 inches, while the jacket would be bored to be exactly 6 inches.

GUN CLASSIFICATION

The different types of guns in use may be roughly divided into four classes.

Mortars—These are pieces with very short barrels, seldom more than 8 calibers in length, which operate against their objective with plunging fire. A mortar is used at elevations between 45 degrees and perpendicular. It should be explained that the term caliber, as applied to ordnance work, means the number of times the diameter of the gun is contained in its length. Thus a 12-inch gun, 45 calibers long, would be 45 feet in length.

Howitzers—These are used for plunging fire and are also guns of relatively low velocity, seldom exceeding 1,500 feet per second. They are between 8 and 15 calibers in length and operate between the elevation angles of 15 and 45 degrees.

Field guns—These are guns of high velocity, seldom operated at an angle exceeding 15 degrees and depend upon velocity for the depth of their effective range. They have muzzle velocities up to 2,000 feet per second and are from 20 to 25 calibers long.

Rifle—There are naval and siege rifles. These pieces are from 40 to 50 calibers long and employ velocities above 2,000 feet per second. Their range is very great and their accuracy of fire much superior to that of field guns. Although they are longer and therefore harder to mount, some large rifles have been used on railway carriages by the French, and the British have also mounted their excess naval guns in this way.

The requirements of field artillery are threefold—that it be mobile, that its fire be accurate and rapid and that repairs can be easily made. In late years mobile artillery has come to include almost every size and type of gun. Howitzers as large as 16-inch have been constructed which can be removed in a few minutes, should the enemy artillery commence to find their range. Some guns as large as 12-inch have been mounted directly on wheel carriages which can be hauled away by tractors. Railway mounts have been developed which will carry almost any gun which can be designed. Almost every type of gun, therefore, except those permanently mounted, may be called mobile. The really mobile artillery, however, includes the light guns—those below 5-inch, which are either horse or tractor drawn and can be operated over any kind of ground. The limit of weight in these pieces is usually about 8,000 pounds for the gun and timber. The distribution of weight is very important. If there is too much weight on the wheels, the gun will become

mired in soft ground; the weight per wheel is usually kept below 2 tons. In the 4.7-inch howitzer the gun itself can be detached from the recoil mechanism and slid out on the trail, helping to distribute the weight. Abroad, the piece is sometimes disassembled and then carried on separate wagons.

RAPIDITY OF FIRE

Rapidity of fire is obtained by the use of a breech block which is light and easily operated, needing only a small angular turn to lock it firmly in place, and by the use of fixed ammunition, with the propelling charge carried in a copper case firmly attached to the base of the projectile. In the latest designs the breech block is closed automatically when a shell is thrown into the chamber of the gun and the empty cartridge case ejected when firing has been completed. As high as 30 shots per minute have been fired from a 75-mm. gun in practice, and while this is not a practical way in which to use the gun, it demonstrates the advance of artillery science. Even the great howitzers in use abroad can be fired at intervals well under a minute, which shows the gain above the guns of a few centuries ago, when the damage done by one shot could be repaired before the next shell arrived.

The non-recoiling carriage, which preserves the alignment of the piece, has also helped to increase the rapidity of fire.

ACCURACY OF FIRE

Accuracy of fire has been improved by the refinements introduced in ammunition and fuses and a more complete understanding of the functions of the rifling in the tube. At present the rifling not only gives the shell the necessary rotation that it may maintain its flight, but also arms the fuse.

OPERATION OF FUSES

Looking at the sketch of a fuse, Fig. 10, we will understand how this is accomplished. The left-hand section shows the firing point below the collar of the striking weight. Should the shell be dropped or struck when the pin is in this position the fuse would not ignite, but if the pin were above the collar, as shown in the central section, the firing point would be forced into a detonator, which would ignite the powder train and explode the shell. When the shell rotates the two lugs shown in the right-hand section tend to move outward, but until the centrifugal force can overcome the resistance of the

coiled springs this cannot occur. When the force becomes great enough the lugs move outward, allowing the pin to swing clear and the firing point is raised into the "armed" position. A similar principle is employed in many types of fuses.

Referring to Fig. 10 it will be noticed that *hh* are the two lugs referred to above. There is also a hole in the firing point, corresponding to lugs *hh* (see *h* in left-hand view and *h'* in right-hand view). Normally when these lugs are locked, the shell in revolving throws the pins out, allowing the point to come back into firing position so that if the shell should hit the ground or other obstruction, the detonator or firing cap would be punctured by that firing point and this might explode the shell. This percussion device is used today in the explosive shell.

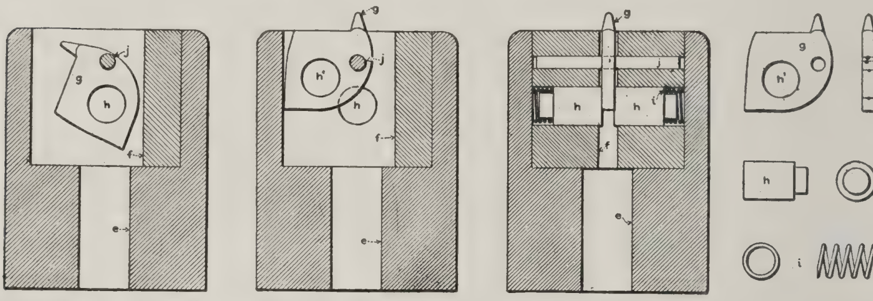


Fig. 10. Illustrating the Operation of Fuses

SIZE LIMITATIONS OF GUNS

I have been asked if there is any limit to the size of guns. Theoretically, there seems to be none, but the practical use of guns automatically sets certain limits. The first limitation is fire control. Unless one is able to observe the effect of the fire and correct any errors, the possession of guns which out-range those of the enemy gives no advantage. The airplane has made observation of artillery fire possible beyond the range of any dream. Railway depots and ammunition dumps miles behind the front lines have been shelled, while hostile aircraft signal the results to their batteries by wireless, corrections being made accordingly. The result of such work was mentioned earlier in this article, but I will repeat it to illustrate my point. On one section of the front the British wished to destroy a freight depot where large masses of munitions were apparently being concentrated. This was more than 10 miles be-

hind the German line and the British guns were 17 miles from their objective. A large gun of about 12 inch diameter was used. Two ranging shots were fired, the second being a direct hit which struck one end of the depot. Five other shots were fired and when the smoke cleared away the aviator who had directed the fire of the guns took a picture of the result. Six shell craters, roughly 50 yards across, were all that remained of this station. If we increase the range, we find that the dispersion of the shots increases rapidly and owing to atmospheric irregularities the probability of accurate fire is reduced. Furthermore, the airplane cannot signal, as its wireless is not strong enough, and therefore, the gun must be fired blindly.

The other limitation is the cost of such super-cannon. A large gun, has, at best, a life of a few hundred rounds and only a small number of these are accurate. The gases corrode the bore much more quickly in large guns than in the smaller sizes, owing, no doubt, to the great amount of powder burned and velocities attained. The great rifles with which the Germans are shelling Paris must have an enormous powder chamber to maintain pressure sufficient to allow the velocity of practically 4,000 feet per second to be reached. This is almost double the velocity of our field guns. It must be nearly 80 calibers long to give the required velocity without exceeding the elastic limit of its material by too large a margin. It is therefore probable that this gun is set upon a permanent foundation and cannot be shifted about. Naturally an objective the size of the city of Paris is easy to hit if the range can be had, for if the shell lands anywhere within the city the Hun will have attained his desire. Such a cannon is expensive to build and this one must have cost a staggering figure. Only the Germans, with their belief that terror will win, could have converted their money into such a cannon. It is far better for us that they would rather spend a quarter or a half million dollars on one gun, the life of which can be measured by days, than to spend the same amount for a large number of field pieces that could put up a barrage fire before our trenches.

GUN INSPECTION

The inspection of artillery material is very rigid. We are bound by wise rules in order that the army and navy may be supplied with the best material and that it will be uniform. Long years of experience have shown that certain requirements must be met

or the men in the field will suffer; rules which are strict but just are enforced. Some persons have complained that this rigid inspection of material costs too much money. In answer to that, is it not better to pay a few dollars more to know that a gun is right and safe than to save those dollars and perhaps spend human life in its stead?

CHEMICAL AND PHYSICAL REQUIREMENTS OF GUN METAL

Our regulations lay down certain requirements for forgings for guns which can be briefly summed up as follows: The chemical analysis is approximately carbon 0.35 to 0.50, manganese 0.50 to 0.80, silicon 0.15 to 0.30 and nickel 2.50 to 3.50 per cent. Sulphur and phosphorus must be less than 0.05 per cent.

The chemical properties are varied to meet the following physical tests:

	Elastic Limit Lb. per sq. in	Tensile Strength Lb. per sq. in.	Elongation Per cent	Contraction of area Per cent
Tubes and jackets...	65,000	95,000	18	30
Small parts and breech blocks	75,000	110,000	14	30

Heat treatment by tempering and annealing is allowed and three official tests only are allowed. If the test pieces submitted do not pass test during one of these three tests, the piece or pieces depending upon the test piece are rejected.

The steel used is a good open hearth or electric steel free from slag and bottom, cast in either open molds or special ingot-casting machines. The specifications demand that the cross-sectional area of the ingot as cast be at least four times the area of the block forging which will be made from it. If bored or punched ingots are used for hollow forgings, the walls must be reduced 50 per cent under the hammer. The lower end of the ingot will always be the breech end, as it is usually more free from defects than the top.

A discard from the ingot of at least 30 per cent by weight from the top and 5 per cent from the bottom is required in all open cast ingots and is slightly less for fluid compressed ingots.

Forgings are made on the hydraulic press, steam hammer or on the drop hammer. The use of the press is usually confined to forging shields and other large plates, the hammer is used for blocks, tubes, jackets, rings, etc., while small parts and difficult sections are made by drop forging.

HEAT TREATMENT

Forgings are annealed above their upper critical point after forging and are then rough machined. After being rough machined they are heat treated so that the steel will be given the necessary physical properties, as called for in the specifications. In heat treating the whole piece, never but a part should be subjected to the same treatment, and this also applies to the quenching operation. Likewise, in annealing, the whole piece should be drawn as evenly as possible and where possible the forging and furnace should be allowed to cool to not more than 200° F. before removing it from the furnace. If this can not be done, the furnace and the piece must be allowed to cool below 600° F. before it is removed and then allowed to cool slowly in air. The last operation in heat treating a piece must always be a drawing or annealing treatment.

No treatment is allowed after the piece has passed test.

Test pieces are usually taken from both breech and muzzle end of the forging, and tangential bars are taken whenever possible. This is because the tangential unit stress is always the limiting feature of gun design, the longitudinal unit stress being much less important.

STANDARD TEST-SPECIMENS

The standard test-specimen is a bar 4.75 in. long, 0.75 in. diameter, threaded at both ends for a distance of 1 in. with a ¾-14 U. S. Standard V-thread. The center position between threads is turned to 0.505 in. diameter for a distance of 2.2 in., filleting into the threaded portion with a 0.375 radius. The 0.505-in. diameter gives an area of 0.2 sq. in.

Machining of finished material must be carried on with utmost care and all dimensions kept within the allowable tolerance as shown on government drawings which accompany the specifications covering the particular material. Rough and careless work and finished surfaces showing chatter or tool marks will not be accepted. Where exceptional finish is required, file and emery polishing are usually specified. Grinding is allowed but surfaces are inspected for seams and cracks before grinding, as that operation usually peens out such defects. Cold "shuts," seams, struts, blow-holes, sand or slag pockets, pipes or any other structural defects are looked for at each inspection and are cause for rejection. Even "ghost lines" of oxide are carefully investigated and if numerous or in dangerous positions, will cause the scrappage of the forging.

GUN FACTORS OF SAFETY

The importance of such rigid inspection can be seen from Fig. 11, which gives the tangential resistance, pressure and velocity curves for a hypothetical gun. As can be seen, the elastic limit of the forging is nearly approached by the compression due to the jacket. The pressure curve shows how the gun is strained during firing. At one point, the value of the tangential resistance is 50,000 pounds per square inch, while the stress produced by the interior pressure is 35,000 pounds per square inch. This gives a factor of safety of 1.43, which is low compared with engineering standards, where 5 is a common figure. We will assume that this compressive strength was obtained by 0.006 inch shrinkage. It is easy to figure the effect that a difference of 0.001 inch above or below the 0.006 inch would have. Say the absolute shrinkage had been

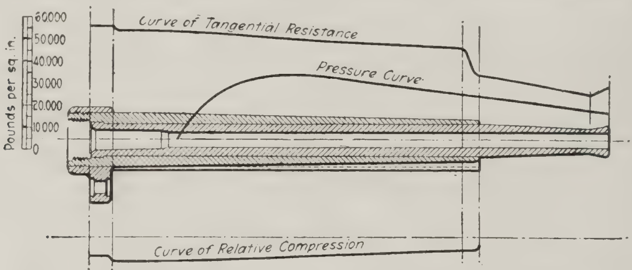


Fig. 11. Curves of Gun Pressure and Tensile Strength

0.005 inch, then the value of the resistance would be reduced to about 40,000 pounds per square inch and the safety factor of 1.14. If the safety factor is reduced below 1, the tube will explode. On the other hand, assuming that the shrinkage is 0.007 inch, the safety factor in the tube will be increased, but the metal of the tube will be stressed above its elastic limit. This in itself is not dangerous, as the walls are well supported, but the danger lies in producing too much strain in the jacket when the internal pressure of the tube is communicated to the outer hoop, with the likelihood of its being split off when the gun is fired.

Is it surprising that when working with such small safety margins we are bound to reject any piece suspected of being weak in the slightest degree? A minute crack in a jacket, too small for the eye to notice in a hurried inspection, may indicate a seam beneath the surface, and is it not better to waste work already done on a piece rather than run the risk of needlessly sacrificing a human life?

Fig. 11 is a cross section through the axis of the gun. Now, when the jacket is shrunk on there will be compression in the inner tube. This is only a theoretical drawing, the tangential unit strength being assumed as 50,000 pounds per square inch. This strength would drop suddenly at the end of the jacket, and the unit stress would be just about the stress of the tube beyond the end of the jacket. The pressure starts at the powder chamber and runs up to the maximum. As the shell travels along, the burning powder cannot keep up that maximum pressure, and it decreases. A velocity curve would show an increase as the shell travels along the bore of the gun. This, we will say, was made with 0.006 inch shrinkage. This means that the outer diameter of the tube was 0.006 inch more than the diameter of the jacket. They were put together by heating the jacket until it was large enough to fit over the tube. With only 0.006 inch shrinkage, which the inspector passed, instead of getting a pressure of 50,000 pounds per square inch in the gun, it will be 35,000 pounds.

As I assumed in my notes, the shrinkage is only 0.005 inch, which reduces the compression and therefore the strength in the tube, at the point where the jacket touches the tube, to 40,000 pounds. Instead of having a factor of safety of 50,000/35,000 we will have 40,000/35,000, or 1.14. Thus it will be seen that one or even a half-thousandth will make a great deal of difference. On the other hand, if the shrinkage is made 0.007 per inch we will get 65,000 pounds per square inch and exceed the elastic limit of the tube. While that will not do much harm it will put too great a stress on the jacket, and when the gun is fired a stress will be introduced in the jacket and it may split off.

ENGINEERING PROBLEM OF THE WAR

We must have guns and guns and more guns. We know that guns are the only weapons with which we can kill the most Huns at the least cost to our own army. Every step in ordnance work must be studied and simplified and speeded up. We are today boring and turning the tubes of jackets at a rate which was believed impossible a few years ago. We are turning out shells by the hundreds from machines that were turning out but dozens before the advent of "stellite" and other cutting metals.

We will cite an example which has lately come to notice of the way that engineering methods have speeded up our work. The rifling of guns has always been a long and tedious operation. A rifling machine consists of a cutting tool carried on a bar which is

made to rotate at the required rate while moving longitudinally through the bore of the gun. The tool thereby cuts a spiral groove in the bore of the gun, the shape of the groove being similar to that of the cutter used. One, two or four grooves have been cut simultaneously, but when more than one set of grooves is cut difficulty is experienced in keeping their depth uniform. Lately this method has been superseded in a certain gun shop by a set of broaches which has cut the time of rifling from 6 hours to 45 minutes for the particular type of gun made there.

Hundreds of other problems in ordnance work will show similar savings of time if they are given the attention which they deserve. Casting, forging and machining problems may be cited, and there are sheet metal problems in the carriage and limber work and difficulties in all branches which can be solved by special jig, fixture or tool work if careful study is devoted to them by our best engineers.

For success armies are dependent upon their equipment, and they cannot gain victories unless they have a superiority of material. The engineers of this country must see that they get the material, not only in the best possible condition for effective use, but in sufficient quantities.

There is no gain in having the best guns in the world or the best planes or trucks, if we have only a few, for the Germans have turned their whole attention to making these articles and are getting out vast quantities of them daily. Unless we have more of them than the Hun, we shall not be able to defeat him quickly and we will have to pay dearly in lives and money, but if we unite and give the problem of smashing his power our full and undivided attention, we will most surely be able to redeem France and Belgium and make the world safe for democracy.

DISCUSSION

A Member:—How accurate must the tripod mounting of the machine guns be made? I heard the remark not long ago that a machine gun, like a lawn sprinkler, does not require very great accuracy in the parts of its mounting. I refer not so much to the machining as to the clearance of rotating parts and traversing arc, and end play in the elevating screw.

Lieut. Skerrett:—The specifications for parts of the gun must be lived up to, and they must be machined accurately, so that when put together there will be no shake and chattering, or vibration due to looseness in the mounting.

The Member:—The material in the inner tube, initially in compression, as I understand it, is in tension every time the gun is fired, and then comes back again. Would this not cause fatigue of the metal?

Lieut. Skerrett:—I do not believe the reversing from compression to tension and back again occurs enough in the ordinary life of a gun to give much trouble. It may in some of the lighter field pieces, but they are not usually compressed to a dangerous extent, nor would the reversion produce crystallization or failure of the material.

Chairman Hinkley:—Is the tube in compression when at rest?

Lieut. Skerrett:—It is in compression when at rest, and in firing it is in tension. The jacket is always in tension.

Creusot 75-Millimeter Gun

N. C. Banks (A.S.A.E.):—We have heard a good deal about the Creusot gun and how successful it was at the beginning of the war. It is still in use. I am told its success is due to the recoil mechanism. Why have the Germans never been able to imitate that? I asked in Paris once about the secret of this gun's recoil and was told that it was one of the things they could not show me. A number of 75-mm. Creusot guns have been captured, we know, and why are the Germans not able to imitate them so as to obtain accurate firing while taking up the recoil?

Lieut. Skerrett:—The French seem to be able to destroy those guns before they are captured and thus keep the secret. On all guns (especially the hydro-pneumatic guns, which employ a liquid and compressed air for returning the gun into firing position after it has been discharged) there is a way of determining the size of the orifice through which the liquid is forced, and also of obtaining a proper recoil buffer. Those two points are the hardest to imitate and the formula by which they are obtained is hard to work out.

The pressure developed in retarding the gun is what slows the gun up and then brings it back into its firing position. The design of this orifice is very complicated; a sort of butterfly valve, fitted into the rifling of the cylinder, rotates under the guidance of the rifled grooves and in so doing increases the size of the orifice, or, as in the case of the "75," a throttling bar is used. (See Fig. 6 and the description which follows.) The French have worked over the design of this orifice ever since 1870, but they did not perfect it until about 1898 or 1899. They spent twenty years

designing just one gun. The Germans did not have an opportunity to get hold of a gun of this type until 1914, and they could scarcely succeed in designing one which would equal it in three or four years.

Mr. Banks:—They claim they had succeeded in getting the design before the war broke out.

Lieut. Skerrett:—Well, their guns do not show it.

C. F. Jeffries (M.S.A.E.):—Only a few months ago I saw in the magazine, *Artillery*, a picture of German artillery and officers stationed on the German eastern front. It was a picture of action behind the German lines, and in it were French "75" guns. The picture may have been a fake, but it showed the same gun down to the most minute detail that could be seen in a picture—the same construction of breech, and nothing to show that there was any difference at all.

Lieut. Skerrett:—They may have been French guns, but I doubt it. They might have been, like the tractors, sent over in catalogues. The Germans have used a design of the same type for the breech block of their field guns for twenty years. The breech is offset, with the load hole below, as in the French gun. The bore of the gun is above and the breech block is slid around and the shell inserted; then the breech block is brought through a half turn, solid against the back of the shell.

A Member:—How many rounds is the life of ordinary field artillery? It is my understanding that the rifling of the guns gives out, and that they are then scrapped. Could not shells slightly oversize be used?

Lieut. Skerrett:—After a certain number of rounds, it varies with the gun and the conditions under which it is fired, the guns are usually rebored, a liner is inserted and the guns rerifled. They are not allowed to make oversize shells.

A Member:—The paper refers to an accuracy of a thousandth of an inch in boring. In turning a 6-inch shrink surface what method is used to maintain that accuracy? Is the barrel ground on the outside, or simply turned smooth?

Lieut. Skerrett:—The usual practice is to grind it. We do not expect the jacket to come to us bored to a thousandth of an inch all the way through. As a matter of fact, we get a jacket supposed we will say to be 6 inches, but it will be 5.992 inches one place and further down 5.991, and in another spot 5.989 inches. Now we have to put a 0.006-inch shrinkage on that. We lay out a tube drawing; the dimension at the first point would be 5.992+0.006, that is, 5.998 inches. At the second point it will change to 5.997

and at the third point it would be 5.995 inches. With such a drawing we can turn a tube which will fit the jacket, because it is always easier to turn an outside surface than an inside one.

A Member:—I should think there would be considerable variation in a long tube.

Lieut. Skerrett:—There is, but in boring guns we get good results, because very little is taken out in the last boring, sometimes only two or three hundredths of an inch.

The guns are reamed with a packed bit whose cutting edges are sprayed with oil and are micrometered to an exact size. The reaming bits are entirely lined with wood, just to diameter. The first one takes out 3/8 inch, the second rougher takes out only a couple of hundredths of an inch.

H. M. Jerome (M.S.A.E.):—Lieutenant Skerrett has used a wider range of limits in his illustrations of jacket-bore dimensions than would be found in actual practice.

A Member:—I once visited a gun shop and saw them taking those measurements every inch. The jacket diameter was some 30 or 40 inches, and I do not know how many reamers they ran through it. The amazing part of this micrometering is the accuracy with which the old workmen can take the measurements in those big, long holes. I do not know just how they do that today, but then what is known as a star gage was used. It is a micrometer gage about a yard long which is placed in the bore but is read on the end.

A Member:—Does not the scale produced in heating the jacket have some effect?

Lieut. Skerrett:—The heat is only moderate, very seldom above 750°. Scale will not form at that temperature.

A Member:—What method is used in attaching the insert or liner to a worn gun?

Lieut. Skerrett:—We rebore the tube. Sometimes, if it is a small gun, we bore out the tube entirely. The jacket goes over the tube, as in the original gun. This is pinned in with a lock or key, so that it will not revolve when the shell starts through it.

Verne Jackson:—How is the liner put in?

Lieut. Skerrett:—It is shrunk in; the entire gun is heated.

J. G. Smith:—What is the method of shrinking the jackets on? Of course they are heated, but how are they handled? Are they swung on horizontally?

Lieut. Skerrett:—They are put on in a vertical position usually; the tube is stood upright and the jacket dropped over it. Sometimes the jacket is held and the tube is dropped into it.

This depends on which method is preferred. The jacket is then cooled at the breach end and shrinks around the tube compressing it. We always try to get a grip at the breech shoulder of the tube and draw the rest of the jacket that way as it cools.

LONG RANGE GUNS

George Ainsworth:—Have American artillery officers ever developed a gun to compare with the long-range German gun?

Lieut. Skerrett:—That I do not know. Back in 1875, Ingalls, at Fortress Monroe, who was the artillery expert of the army at that time, stated that it would not be hard to develop smoothbore guns with a 50-mile range. I think it would be possible to develop them, but I do not know that we ever have.

C. P. Geen:—In wire-wound guns, which are still used considerably, is the tube in compression, and if so, how is it put in compression; in winding the gun?

Lieut. Skerrett:—It is just like wrapping a rubber band round one's finger. First one thin jacket and then another is applied. In other words, the compression is cumulative.

STREAM LINE SHELLS AND VACUUM EFFECT

Mr. Geen:—Has any serious thought been given to decreasing the vacuum or eddy behind the flat back of shells? This is considered to have a great retarding effect.

Lieut. Skerrett:—The high-powered guns we are using now create a vacuum behind the back of the shell, but I do not know the amount of the actual retardation. Whitworth, in 1866, had a curiously shaped shell for a gun with a twisted hexagonal bore, one turn in twenty-five. The shell looked like a loaf of bread, and it acted in flight just as a loaf of bread would. I do not know that a shell with stream lines would have a considerable effect on the range, nor do I know that it has ever been tried.

Mr. Geen:—I understand that one that was tried had a detachable piece on the end, which flew out from the projectile after a comparatively short distance. That piece had a flat back and was bored to fit the projectile, but the projectile, I believe, was heavier at the front and followed an oscillatory motion.

Lieut. Skerrett:—The only objection to giving it a stream-line form is that the driving band is so far forward. When we place

a shell in the bore of a cannon we want to have as good a surface as possible for the gases to act upon and in order to prevent all losses around the edge of the shell; we are dealing with pressure up to 35,000 to 40,000 pounds per square inch, and they are hard to hold.

C. C. Hope:—All powder cases have thus far been made of brass or copper. Is there any reason why steel could not be used?

Lieut. Skerrett:—The brass case acts as a seal for the powder chamber. A steel case will work all right at first, while the gun is new, but when there is a clearance of a thousandth of an inch the steel will not expand enough to hold tightly to the walls all around. There will be leakage and this will cut down the efficiency of the gun a great deal. Besides this, steel will not stand the pressure of the discharge of a gun, as it is liable to fracture.

RIFLING METHODS

R. G. Handy (Jun.S.A.E.):—How is the broaching done, and how deep is the rifling?

Lieut. Skerrett:—Broaching has not been tried on these larger guns as yet. It has been tried with small guns only. Up to this time we have cut one or two grooves at once or even four, by changing the position of the head-stock from point to point as the grooves are put in. What we do nowadays is to put on a cutter and outline the rifling all the way around. It can be done in one operation. Broaches that take anywhere from 0.002 to 0.003 inch at a cut are run through. The rifling is about 0.002 inch deep.

Mr. Handy:—What is the relation between the diameter of the bands on the shell and the bore of the gun?

Lieut. Skerrett:—It is slightly larger than the bore of the gun, to insure that the copper is driven tightly into the rifle grooves. This soft copper driving band is forced down into the groove as the shell is driven forward.

C. G. Cowles (M.S.A.E.):—What is the clearance between the shell and the bore?

Lieut. Skerrett:—It is usually 0.01 inch or less. However, some of them are more.

DOUBLE-ACTING SHELLS NOT PRACTICABLE

Mr. Cowles:—One of the main stresses in firing is the longitudinal stress which has to be counteracted by means of the inertia of the gun carriage and the gun, plus the resistance of the recoil

mechanism. As I understand it, that is difficult to do in such frail carriages as airplanes. Furthermore, it is difficult to bomb such objectives as railway stations, owing to inability to aim accurately. The shell should be shot and not dropped in order to obtain the accuracy desired. Why is it not possible, instead of supplying an airplane with a mechanism that may tip it over or perhaps destroy it, to design a double-acting shell, so that, while one shot would be wasted in going in the opposite direction, still it would supply the force which would do away with the kick on the machine?

Lieut. Skerrett:—The French designed and tried out a "one-pounder" acting on just about that principle. It had a double barrel, a one-pounder at one end, and the other was more or less like a choke-bore shotgun. A double-ended cartridge with a side percussion cap was fed into it. This took an ordinary one-pound high explosive shell and a cartridge loaded with buckshot and very close wadding. Action and reaction being equal and opposite, theoretically there would be no recoil with this gun, which was mounted on the frame of an airplane. Unfortunately it did not work out. The first time it was tried the choke-bore jammed and the result was that the full charge, supposed to blow this out at a reasonable velocity and also to act in the opposite direction, all went one way, and the gun blew off the other way with most of the airplane.

One may say that to overcome this trouble it would be necessary to use exactly the same charge and type of shell on each end. The trouble with this plan is that it would be liable to shoot back into our own lines.

FIELD FOR AUTOMATIC MACHINERY

Mr. Cowles:—The author states that every step in ordnance work must be studied, simplified and speeded up. I am sure all of us agree with that statement and I suggest that this can be done by extending the use of automatic machinery into newer fields. I believe we could go into almost any shop and get much more speed out of perhaps one or more operations, just by introducing automatic feeds. For instance, I saw one shop where men were bending sticks for airplanes. About 200 of those sticks are required for one machine and one man feeds and bends about 400 an hour. I believe it is possible to get 180,000 a day per man with perhaps less effort on his part. We are all familiar with automatic screw machine work. For many years knitting machines have been doing most intricate work automatically.

Chairman Hinkley:—This war business is new. There are as many automatic devices used in straight commercial work as in the knitting mills. If war were business we would be tooled up for it on an automatic basis inside of three years, without a doubt.

Now, there is always the question as to whether we will get tooled up ahead in time to use our improvements. In the meanwhile, we are trying to increase our mechanical efficiency with such tools as we have. Trench-hat making is almost automatic in all its phases. If this were a business that would go on indefinitely, no doubt we would be properly tooled up for it, but the expenditure must be limited by the size of the order. A firm might get an order for three or four million trench hats, yet be out of business in about six months with all the machinery on hand.

SERIOUS FAULTS OF WIRE-WOUND GUN

A Member:—Why should the Government discard the wire-wound rapid-fire gun?

Lieut. Skerrett:—A long gun is usually supported in the middle. It has a bending moment that tends to make the gun droop, and the middle section must be built up strongly enough to prevent this. The wrapped gun is rigid enough at first but the layers start to working over each other every time the gun is fired; owing to the expansion of the metal, the droop develops and finally the end gets blown off.

DIFFICULTY OF FIRING AT AIRPLANES

A Member:—Why is it that a field gun will shoot four or five miles, yet when aiming at a plane 16,000 or 17,000 feet high it is not as effective?

Lieut. Skerrett:—Shrapnel is ranged for 22 seconds' flight. That is only at the 15 degree angle, the ordinary angle we have always used. If we went up to 45 degrees it is more than likely that we could double the range at the same velocity. Shooting at 15 degrees will give, say, 22 seconds' flight. If we are shooting at an airplane at the maximum range of the gun, the aviator, seeing the flash, can turn and be a mile away before the shell gets there.

We must know how much of a lead to give because those fighting planes fly at 130 to 140 miles per hour, and even in 22 seconds they are a mile away. We must aim a mile ahead to have any chance of hitting one, and we must count upon its flying straight.

Ernest Goldberger:—At what angle does the gun shoot most effectively?

Lieut. Skerrett:—At about 43 degrees.

A Member:—Can a plane fly higher than we can shoot, or can the gun shoot higher? Do anti-craft guns need to be stronger because they shoot vertically?

Lieut. Skerrett:—It can outrange the planes, but the chance of hitting them is small. It may be that the anti-aircraft gun is stronger than the field gun. It does not necessarily need a greater powder charge for the vertical work, if they use the same velocity as a field gun.

ARMOR-PIERCING PROJECTILE'S ACTION

Mr. Ainsworth:—What is the difference in construction between the armor-piercing projectile and the high-explosive shell?

Lieut. Skerrett:—The armor-piercing projectile and the high-explosive shell have different shapes. The latter is filled with high explosives and detonates against the side of the armor. The armor-piercing projectile has a great mass of metal and besides it has a cap of soft iron. When that hits the plate it keeps the shell from splintering at the nose. The projectile punches its way right through and will not explode until it is through. The exterior covering not only gives it a "bite," but acts as a lubricant.

GODFREY WEITZEL

By

Lieut. James H. England,
Engineers, U. S. Army.

Godfrey Weitzel was born at Cincinnati, Ohio, November 1st, 1835. He was graduated in the class of 1855 at the Military Academy as a Brevet Second Lieutenant, Corps of Engineers.

From his graduation until 1859 he served as Assistant Engineer on the construction and repair of the defenses in the vicinity of New Orleans. From 1859 until the beginning of the Civil War he held the position of Assistant Professor of Engineering at the Military Academy. In 1860 he was promoted to be a First Lieutenant, Corps of Engineers.

During the trying times at Washington, D. C., immediately preceding and following the first inauguration of Lincoln, Weitzel served with Company A, Engineers, on duty in the Capital. Later, in April, 1861, he accompanied the same organization when it moved to the defense of Fort Pickens, Fla. From October to December of the same year he was Chief Engineer on the staff of Brigadier General Mitchel, constructing fortifications for the protection of Cincinnati, Ohio. In January and February, 1862, he was in command of a company of Sappers and Miners in the defense of Washington. D. C.

The expedition against New Orleans was organized in the latter part of February, 1862, under Major General Butler. Weitzel was assigned as Chief Engineer on General Butler's staff. This was due in part to the knowledge of Louisiana he had gained in his four-year tour of duty there. It was this knowledge combined with dash and bravery that led General Butler, upon the capture of New Orleans, to appoint him Military Commander and Mayor of the city. Early recognizing the value and merit of the young lieutenant, General Butler, then in command of the Department of the Gulf, was instrumental in having him appointed Brigadier General of Volunteers, in August, 1862.

About the latter part of August, 1862, the Confederate General Taylor arrived at Opelousas with orders to enroll troops in Louisiana. In October Butler sent Weitzel to dislodge them. He advanced from Donaldson on the 26th of October with 2,300 men and four light-draft gun-boats; met Moulton at Labadieville; and drove him back across the Teche. Weitzel could advance no further as the water in the bayous at this time was too low.

For gallant and meritorious conduct he was brevetted Major in October, 1862, and, in the following March, was promoted to be Captain, Corps of Engineers. During April and May, 1863, he was in command of the advance in Major General Bank's operations in western Louisiana and engaged in the combat of Camp Bisland and in several skirmishes in pursuit of the enemy.

At the seige of Port Hudson, Weitzel commanded a division. He was young, buoyant and combative and took a very active part in the assaults on May 27th and June 14th. For his splendid work in the operations at Port Hudson he was brevetted Lieutenant Colonel in July, 1863.

As a division commander in the 19th Army Corps, he took part in the Lafourche campaign, the expedition to Sabine Pass, and the western Louisiana campaign. In the operations before Richmond, in May, 1864, he commanded the 2nd division, 18th Army Corps. During the summer of 1864 he was Chief Engineer of the Army of the James and was engaged in the action at Swift's Creek, the operations near Drury's Bluff, and the construction of the defenses of Bermuda Hundred, James River, and Deep Bottom.

In the repulse of the enemy's assault at Fort Harrison in the fall of 1864. Weitzel commanded the 18th Army Corps. As corps commander he was also engaged in the assault of the enemy's lines on the Williamsburg and Nine Mile Roads. For distinguished services during the rebellion, he was brevetted Major General, U. S. Volunteers in August, 1864, and Colonel in September of the same year, for his excellent conduct at the capture of Fort Harrison. In November he was appointed Major General, U. S. Volunteers. On the first expedition to Fort Fisher in December, 1864, he was second in command.

In General Grant's final operations against Richmond in 1865, Weitzel commanded all troops north of the Appomatox River. When the Confederate Capital finally fell, he took possession. This event crowned his brilliant military history. Perhaps nothing

but Lee's surrender gave the North such heart-felt joy as the following simple message:

Richmond, Va., April 3, 1865.

Hon. E. M. Stanton, Secretary of War:

We entered Richmond at 8 o'clock this morning.

G. WEITZEL,
Brigadier General Commanding.

For his services in the Richmond campaign he was brevetted Brigadier General, U. S. Army, in March, 1865, and Major General, U. S. Army, on the same date, for his faithful performance of duty during the entire war.

In the spring of 1865 he commanded the District of the Rio Grande. He was mustered out of Volunteer Service in March, 1866. In July, 1866, he was placed in charge of the construction of Forts Knox and Popham, Maine. From 1867 to 1873, he was stationed at Louisville, in charge of various works of improvement on the Ohio River. Here he gave himself whole-heartedly to the completion of the Louisville and Portland Ship Canal. The Ohio River falls 26 feet at Louisville and the canal provides the means of overcoming this obstacle to navigation. The locks were, at that time, the largest in the country, being 372 feet between mitre posts, 80 feet in width, and with lifts of 12 and 14 feet.

Transferred to Detroit in 1873, General Weitzel was placed in charge of several works of river and harbor improvement, and of lighthouse construction on the Great Lakes. The enlargement of the St. Mary's Falls Canal was one of the most important pieces of construction during his term. A new lock, 515 feet long between mitres, 80 feet wide, and with a lift of 18 feet, bears mute testimony to his skill in construction.

Another monument to his ability as an engineer is the lighthouse on Stannard's rock. This light-house is located on a rocky shoal in Lake Superior, about 30 miles from the nearest land. The focal plane of the light rises 101 feet above the water.

Failing health led to his transfer to the less severe climate of Philadelphia in 1882. Here he had charge of the various works of improvement and was chairman of the Commission Advisory to the Board of Harbor Commissioners of Philadelphia.

Despite his removal to a less rugged climate than that of the Great Lakes, the expected recovery of health did not occur. He

died two years later, on March 19th, 1884. In announcing his death to the Corps of Engineers, the Chief of Engineers said:

> A distinguished soldier, an accomplished engineer, a genial friend, true to the noblest instincts of manhood, faithful in the discharge of every duty, the Corps of Engineers mourns to-day the loss of one of whose well-earned fame it may justly be proud.

Integrity, straightforwardness, breadth of mind and clear good sense are but a very few of General Weitzel's attributes. The greatest thing about him was his ever-youthful directness and simplicity of character. It was his young, fearless, and intrepid conduct that brought him honor and position in the Civil War. It was this same spirit that made his peaceful pursuits so successful. And, finally, it was this spirit that made him honored by his country, loved by his family and respected and admired by his friends.

OXY-ACETYLENE WELDING

TAUGHT AT THE ENGINEER SCHOOL, WASHINGTON BARRACKS, D. C.

By

Capt. George B. Malone,

Engineers, U. S. A.

The Oxy-Acetylene Welding School, in operation at Washington Barracks, D. C., is under the supervision of the Corps of Engineers, U. S. Army.

The pupils are taught that autogenous welding is uniting by heating without hammering or compression. The oxy-acetylene flame temperature is approximately 6,300° F., being more than double the hottest solid fuel known. By this process, iron, steel, cast iron, aluminum, brass, bronze, copper, platinum. money metals, and other metals can be so perfectly united that when smoothed, or dressed, no joint can be discerned. With the oxy-acetylene torch for cutting metals, which employs additional stream of pure oxygen, steel and iron—other than cast iron—can be cut very rapidly. The course is divided into problems which take care of every necessary detail that is likely to be encountered during the present emergency; for instance, the welding of broken automobile parts, steel, aluminum, brass, bronze, and in fact any metal part of an automobile that is broken. The cutting course includes such work as demolition of steel girders, heavy castings that in a sense fit the men for cutting up guns of large caliber, and in fact any metal that can be cut by the oxy-acetylene torch. The men are provided with goggles of the type that is most suited in the eyes of the individual man. The reason that so much care is taken of each individual operator's eyes is that while good goggles can be furnished, very few operators' eyes test the same when examined for vision after using the oxy-acetylene torch. When cutting light metals, there is no need for using goggles unless the operator is in a small or confined space, where there might be danger of sparks, or in the cutting of metal that has become rusted from exposure to the elements which form a great amount of scale that has to be burned away before the piece

or parts can be cut. These sparks are very liable to fly and injure the operator's eyes. It is poor practice, however, to use the same glass for cutting as for welding. Leather aprons are provided, which are patterned after the blacksmith's type of apron with the slit eliminated. This prevents the man's clothes from being burned while working. No general rule can be given as to how to hold the torch, and the men are taught to hold it in the way which seems most natural.

The course in oxy-acetylene welding at Washington Barracks covers approximately thirty days of intensive training, divided as follows:

Problem No. 1: The Welding Torch (1 day)—

(*a*) Nomenclature and care of oxy-acetylene welding torch.

(*b*) Lighting torch, showing correct welding flame, and the effect of improper regulation.

(*c*) Repairing of welding torch, showing by actual demonstration how it can be repaired.

(*d*) Repairing and care of welding tips, showing the danger in repairing, particularly the cleaning of the orifice with steel wire and other hard materials.

(*e*) Repairing of oxygen regulator, instructing the operator in the replacement of various parts. The effect of oil and grease on them, and the necessity of the safety valve being in good order.

(*f*) Repairing of acetylene regulator in the necessity of the precautions necessary to prevent it catching fire, on account of the different parts becoming loose and hose connections not being properly wired.

Problem No. 2: The Cutting Torch (5 days, at various times during the course)—

The pupils are instructed that the cutting torch cannot be used for welding any more than the welding torch for cutting. The same acetylene regulator is used, but when work over 2 inches thick is to be cut, a special high-pressure oxygen regulator must be employed.

(*a*) Lighting of Torch—

The same method employed in connection with the welding torch is applied to the cutting torch, and each operator is furnished with a patented lighter manufactured especially for this use. The acetylene valve is opened slightly, and the torch lighted. The

Students at work, Oxy-Acetylene Welding School, Washington Barracks, D. C.

oxygen for the heating flame is then turned on, and adjusted until a neutral heating flame is produced. When the piece to be cut has been heated sufficiently to bring the edge to a cherry red, the valve which allows the extra jet of oxygen is turned on; then the operator is ready to make the cut.

(*b*) Repairing of Tips—

Great care must be exercised in cleaning the cutting tips. If tips become obstructed in any way, due to any beads of iron splashed over the face of same, or from any other cause, a copper wire and a copper-wire brush is used to clean them. No hard or sharp implements are allowed to be used for cleaning tips.

(*c*) Repairing of High-pressure Regulator—

A great deal of instruction is given in the repairing of oxygen regulators, as it is most important that each operator know what the vital parts are that will be liable to give trouble when in the field on active work. Great care is exercised also in teaching the men that the repair parts of the low- and high-pressure oxygen regulator are so very similar that a mistake can easily be made.

Problem No. 3: Welding Light Sheet Steel (2 days)—

(*a*) The size of the torch tip to be used for this particular work is decided upon; and all depends upon the thickness of the metal that is to be welded. In case of a butt weld on metals under one-eighth inch in thickness, where no beveling is necessary, the edges of the two parts to be welded are heated at the same time and brought to a fusion point. A rotary motion of the torch insures a practical weld, enabling the two edges to flow together.

(*b*) Welding Heavy Sheet Steel with Filler Rod—

The same heating that applies to light sheet steel welding applies to heavy sheet-steel welding; that is, to bring both edges that are to be welded and the filler rod to a fusion point at the same time. When all three are sufficiently preheated, a portion of the rod will immediately adhere to the edges that are to be welded. Whenever possible, the welding flame is directed toward the metal which is being added.

(*c*) Beveling of Steel Plate—

The heat is not confined to the line of weld. The movement of the torch is such that it will heat a small area near the weld. This applies particularly to iron and steel.

(*d*) Steel Castings—

Preheating is a very important part of the welding of steel castings, although if the castings to be welded are light in weight, it is found that they are elastic enough to take up the strain of expansion and contraction without breaking. However, in welding heavy steel castings; in fact, in welding even light steel castings, it is found that preheating will save from 30 to 50 per cent in gas and labor, as welds can be made faster on previously heated metal. Dressing also plays an important part in the welding of steel castings, and this is prepared with great care to insure a perfect fusion. It is found that there is no necessity to teach spot welding, as the operators who have passed the test in sheet steel and steel casting welding are familiar enough with the process to make a spot weld whenever necessary.

Problem No. 4: Cast Iron Welding (2 days, at various times during the course)—

Cast iron is welded under the same conditions as cast steel, and all work of a heavy nature is preheated. This preheating may be done either by a welding torch or a kerosene preheating torch and both methods are employed with the help of a charcoal fire at times in this school. Fluxes are used in the welding of cast iron, both of a light and heavy nature, the reason for same being that some metals do not flow together readily under the action of the torch, and, at the same time the flux acts as a cleaner, bringing the impurities in the parts that are to be welded to the surface, where these are scraped from the part or casting with the aid of the filler rod. Flux at all times is used sparingly on account of the scale which forms on top of the weld, and which makes it particularly hard to machine or finish. Fluxes are kept in air-tight tins, as they absorb moisture and become useless if exposed to the air for any length of time.

Problem No. 5: Welding and Brazing of Brass, Bronze and Malleable Iron (2 days, at various times during the course)—

1. Brass and Bronze—

(*a*) Welding of brass and bronze is quite simple; preheating is not necessary, except from a point of view of economy.

(*b*) The filler rod for welding brass and bronze is made of pure metal in which is incorporated a small quantity of aluminum necessary to deoxidize the weld.

(*c*) The flux used for brass and bronze consists of ordinary borax powder, fused to what is known as borax glass, and then crushed to pass through a No. 20 mesh screen.

2. Malleable Iron—

Malleable Iron is probably more difficult to weld and treat than any other metal, as castings that have been made malleable will lose their qualities when welded. In case of malleable parts broken in service, and where the repair is to be made by the welding operator, it is prepared like cast iron, but as a filler rod, Tobin bronze is used with a brass or bronze flux. This gives an exceptionally strong joint. The metal in the near neighborhood of the weld, however, is not malleable, but the tenacity with which the bronze adheres to the iron and its own ductility will compensate for this.

Problem No. 6: Welding Copper (1 day)—

(*a*) As heat radiates from copper very rapidly, and the fact that copper is an exceptionally good conductor of heat, it is found better to preheat the parts to be welded to a cherry red before starting to weld.

(*b*) Preparation—

Copper parts and steel castings are prepared for welding similar to steel and iron. A tip considerably larger than the one used for the same thickness of steel is used.

(*c*) Fusion Method—

In some cases, particularly electrodes, flux is not needed. Fusion method as applied to steel applies to copper.

(*d*) With Filler Rod—

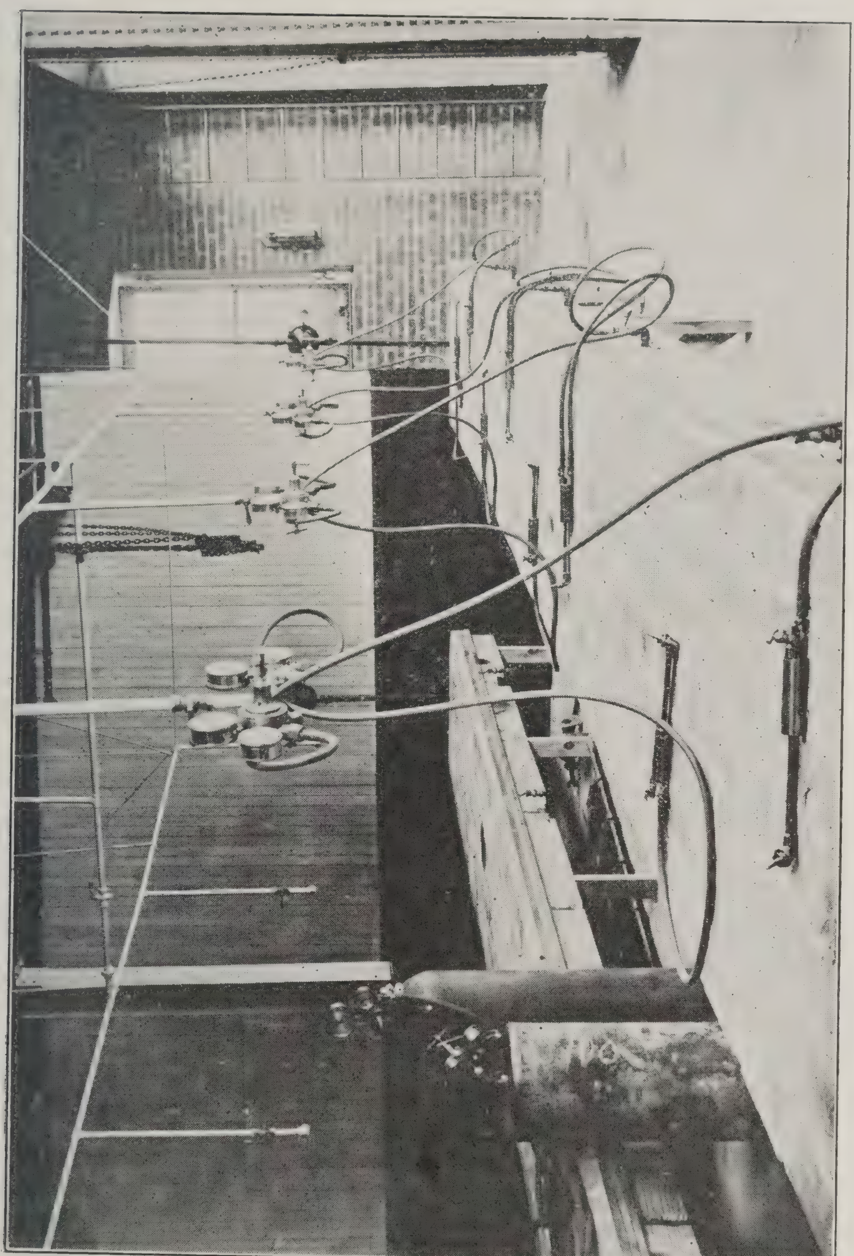
The filler rod that is employed is manufactured with copper with a large amount of phosphorus; phosphorus being one of the best deoxidizing agents for copper known.

(*e*) Flux—

When flux is used, particularly on repair parts, borax glass is used as in the case of bronze, brass and malleable iron.

(*f*) Execution of Welds—

The filler rod is not added until the edges of the parts to be welded are in a malleable condition; then the operation proceeds rapidly to prevent the heat from spreading.



Equipment layout, Oxy-Acetylene Welding School, Washington Barracks, D. C.

Problem No. 7: Welding Sheet Aluminum (2 days)—

Welding of sheet aluminum is as a rule given to the pupils first, and the fact that it is generally pure metal makes it necessary to be handled somewhat differently from an alloy. The sheets average not over one-eighth of an inch in thickness.

(*a*) Pure drawn aluminum rod is used as a filler.

(*b*) Sheet aluminum flux is cheaper to purchase from the manufacturer on account of being manufactured in large quantities. Salt water can be used with a puddling stick to very good advantage in most cases. The solution is heavily saturated in order to work satisfactorily.

(*c*) Preheating is seldom necessary, and any preheating or annealing that may be deemed advisable is done with a torch flame, using an excess of acetylene.

(*d*) Beveling is not necessary, as practice shows that the plates tend to bevel themselves as they come to the melting point along the line of the weld.

Problem No. 8: Welding Cast Aluminum (2 days). Cast Aluminum Rod Used—

It has been found that the welding of aluminum castings at first offered a great many difficulties to the operator, but as he becomes more experienced with this metal, satisfactory results are obtained. The difficulties that have arisen have been due to the fact that aluminum has a low melting point—1,200° F. Due to this fact, a large welding flame is employed on this work. This of course calls for skillful manipulation of the torch to prevent holes being burned in the castings that are to be welded.

(*a*) Preparation—

To insure good work with aluminum castings, the work must first of all be very clean. Most aluminum castings that are welded have generally been in contact with oil and grease. In removing all traces of oil from castings, it takes a considerable amount of time, as the oil penetrates the metal. The castings are first welded slowly over a charcoal fire or with the kerosene preheating torch. The flame is held some distance from the casting; then, as the oil begins to come to the surface, it is carefully wiped away. In some cases gasoline is used to good advantage for cleaning castings. Great care is exercised in the welding of automobile crank cases and other

automobile parts, as they have a tendency to collapse when the metal reaches the melting point. In order to prevent collapse during the preheating operations, a sheet of heavy paper or cardboard is placed next to the back of the crack or break that is to be welded. This paper or cardboard is backed up with fire clay, which has been dampened, and then is packed with asbestos fibre until a firm support is obtained. The paper or cardboard prevents the fire clay from cutting into the weld. Whenever a weld is made close to a bearing, the babbit is removed. Then mandrels are clamped to the bearing to keep them in alignment.

(*b*) The beginner is taught that castings should be preheated, except in cases where the part to be welded is a projecting lug or flange. Preheating, or reheating, when done, is carried on slowly and carefully. Castings are not preheated over 850 to 900° F., as above this temperature the metal gets very fragile and is apt to collapse. They are also taught that when preheating aluminum castings, it is advisable to test the heat of the metal with a stick of half-and-half solder, composed of 50 per cent lead and 50 per cent tin. As soon as this melts on touching the casting, it shows that the work is heated sufficiently and is ready for welding.

(*c*) As many experts' opinions vary as to the method of welding aluminum castings, that is, where the puddling or true welding process is used, both processes are taught. Salt water may be used in either case as a flux, as well as aluminum casting flux, which can be purchased very reasonably from reliable oxy-acetylene welding apparatus manufacturers.

(*d*) The Puddling Method—

There is provided for each operator a ⅜-inch steel rod, about 15 inches long, flattened on one end. The operator is taught to play the torch flame along the line of the weld and bring the latter to a molten state. The surface is then scraped with the puddling rod to remove all traces of dirt and oxide. A little melted filler rod is added, and the puddling rod is used again after dipping in salt water or aluminum flux. The end of the puddling rod is always at a red heat on the end that is employed for the puddling process. Welds that have been made by this process, although reasonably strong, are sometimes apt to be porous and not as apt to be as sound as welds that are made by the true welding process.

(*e*) The True Welding Process—

The torch flame is regulated as in the puddling process. The flame is played along the line of the weld, and a short length of the

same brought to a molten state. Then touch it gently with filler rod after it has been dipped in salt water or flux. A small amount is melted into the weld and the molten metal stirred with the filler rod until it flows evenly. If a uniform flow is not obtained, more flux is added.

(*f*) Care of Castings After Being Welded—

The work is allowed to cool very slowly, and is protected from the air. A tank, or large receptacle, if available, is used, and contains either hydrated lime or raw asbestos. Casting is allowed to remain in same until thoroughly cool. In field practice, however, dry sand or asbestos paper, if available, is used.

Problem No. 9: Lead burning (2 days)—

Under the title of lead burning, it must be explained that for years this trade has been kept a secret process, and only few men have been doing this kind of work. Since the invention of the welding torch, however, this trade has become very much simplified, as the secret formulæ for the gases that were used heretofore are not now needed, and lead burning, with gases made from liquids is practically extinct.

Lead burning, or welding, has become very valuable, particularly in chemical laboratories, and for battery work among the automobile manufacturers, and it is now very common to find even in the smallest garage, or auto repair shop, a lead welding outfit.

Since lead welding has become so important, it is taught at the welding school. Manufacturers of welding equipment have given a great deal of time to the invention of a welding torch which has supplemented the old-fashioned method of welding by gases manufactured from liquids. The acetylene process is not quite as satisfactory for welding lead as is the combination of hydrogen and oxygen, or coal or water gas combined with oxygen. In a great many plants, coal or water gas, combined with compressed air, is being used to very good advantage. The reason for the acetylene process not being as satisfactory as the two already mentioned is on account of the great amount of carbon that is given out by acetylene gas, and also the intense heat that is generated when combined with oxygen.

(*a*) Preparation—

Regardless of the nature of the lead to be welded, it is always remembered that it is positively necessary to have the edges

thoroughly clean by scraping before the welding operation is started. No flux of any kind is used.

Problem No. 10: Test--

Light sheet metal plate is tested by the hammering process, and where possible the tensile strength test is given. The heavy sheet steel test is accomplished also as above. A corrosive test is given with the aid of a corroding liquid, which shows burns and blowholes if there are any. The bending test is also employed.

Problem No. 11: (1 day)—

Nomenclature and care of generators of acetylene gas.

The pupils are instructed in the erection and in the care of the acetylene generator. Great stress is laid particularly on the size of the carbide that is used for the generator. The pupils are also cautioned that when various types of torches are employed, that is, medium or positive type of torch, or the low-pressure torch, injector type of torch, that it is better to use the high-pressure generator, which can be utilized for all types of torches.

Problem No. 12: Examinations (one-half day each week)—

Tests are made at given times to teach the men the idea of getting to a certain point in the quickest possible time, and when arrived at said point, to know just what part of the equipment to handle first, so as to give them the welding flame or cutting flame in the shortest possible time. Examinations take place at the end of each week. These are in the form of questions, and each is in a sense a review of the work of the week previous. The work is tested by the process mentioned elsewhere, examination papers being marked; and the pupils upon graduation are given a card which will identify said party when assigned to special duty.

BOOK REVIEWS.

Topography and Strategy in the War. By Douglas Wilson Johnson, Associate Professor of Physiography in Columbia University. 18 diagrams and maps, 48 illustrations. Henry Holt & Co., 1917. pp. x, 211. 22cm. $2.00.

Among the efforts of prominent scientists to put their work in shape to contribute to the great problem with which we are confronted, this attractive volume is worthy of favorable mention.

The strategist realizes that the choice of his objectives, his base, and his line of operations are influenced by, and dependent upon, the topography of the theatre of war; to the casual observer, the country is regular or irregular, rough or smooth, dismal or beautiful, fertile or sterile, passable or impassable, rich in resources, favorable to agriculture, trade or navigation; Professor Johnson, who has studied the theatre of war in Europe from the standpoint of a geologist, explains the general disposition of those features which make a position easy or hard to traverse, attack or defend, rich in military resources, etc.

He says that he "has found ample indication that the rôle played by land forms in plans of campaign and movement of armies, is no less important today than in the past. To emphasize this interesting relationship between inanimate Nature and the science of War, is one of the objects of this book. Another object, and perhaps the more important, is to place before the reader such a picture of each theater of war as shall enable him to follow with greater ease and livelier interest the movements of our own and our Allies troops. . . . I have endeavored," he says, "to combine scientific accuracy in the descriptions of topography with a treatment which avoids the use of technical terms."

He first describes the Western Theatre, giving a "diagrammatic" view showing the principal plateaus and plains, mountains and lowlands, cliffscarps and river trenches which have influenced military operations, with a cross section showing the underground rock structure. "What is now the country of northern France," he says, "was in time long past a part of the sea. When the sea bottom deposits

were upraised to form land, the horizontal layers were unequally elevated. . . . Since the basin was formed, it has suffered extensive erosion from rain and rivers. In the central area where the rocks are flat, winding river trenches, like those of the Aisne, Marne, and Seine, are cut from three to five hundred feet below the flat upland surface. To the east and northeast the gently upturned margins of the basin exposes alternate layers of hard and soft rocks. . . . It is not difficult to understand why the plateau belts have been called 'the natural defenses of Paris.' " He says that a series of steep east facing escarpments have been formed while the western slope is flat and gentle; that Nancy and Verdun owed their strength to this natural fortification rather than to field or permanent works that have been placed there by man. After describing the physical features of the Western Theatre he gives a brief summary narrative of the military operations there in the first three years of this war, and then treats of the Eastern, Italian, Balkan and Roumanian Theatres, describing in each the mineral resources as well as the physical features of the surface that have a military or political bearing upon the war, and then gives a brief narrative of the first three years of the war.

The thrilling accounts of the campaigns for Italian Irredenta scaling the lofty heights and trenching and tunnelling through the solid rock is of especial interest to the engineer. Through the courtesy of the publishers, we are printing in full the description and narrative of the Balkan theatre. "It will be seen," he says, "that this treatment incidentally provides a summary history of the chief military operations on the several fronts up to the time when America took her place among the combatants.

In addition to the advantages to the general reader this work will help a professional soldier in arranging and grouping the topographical data he has gathered from other sources into such shape to be readily applied in solving the tactical and strategical problems as they arise.

In the physical description, the style is attractive, clear and strong; in the narrative, it is somewhat fragmentary and not so smooth or finished, but clear enough to give with the maps a very good perspective of those events of which the details have been reported in the daily papers. All the narrative can be readily followed on the little maps on which only the prominent features and places and those mentioned in the text are represented. The dia-

grammatic maps would have shown the broad and general features of the land more clearly if they had not been so sketchy and distorted. The volume is well indexed and printed.

The progress of science and civilization demands that specialists should put the best results of their work in shape to be handled by all. The young men who are now taking up their military studies will find in this book a fascinating and helpful introduction to the study of the Great War.

—W. R. Livermore,
Col. U. S. Army (ret'd).

Trinitrotoluenes and Mono- and Dinitrotoluenes. Their Manufacture and Properties. By G. Carlton Smith, B.S., Instructor in General Chemistry, School of Applied Science, Carnegie Institute of Technology, Pittsburgh, Pa. New York, D. Van Nostrand Company, 1918. 133 pages. 20 cm. $2.00.

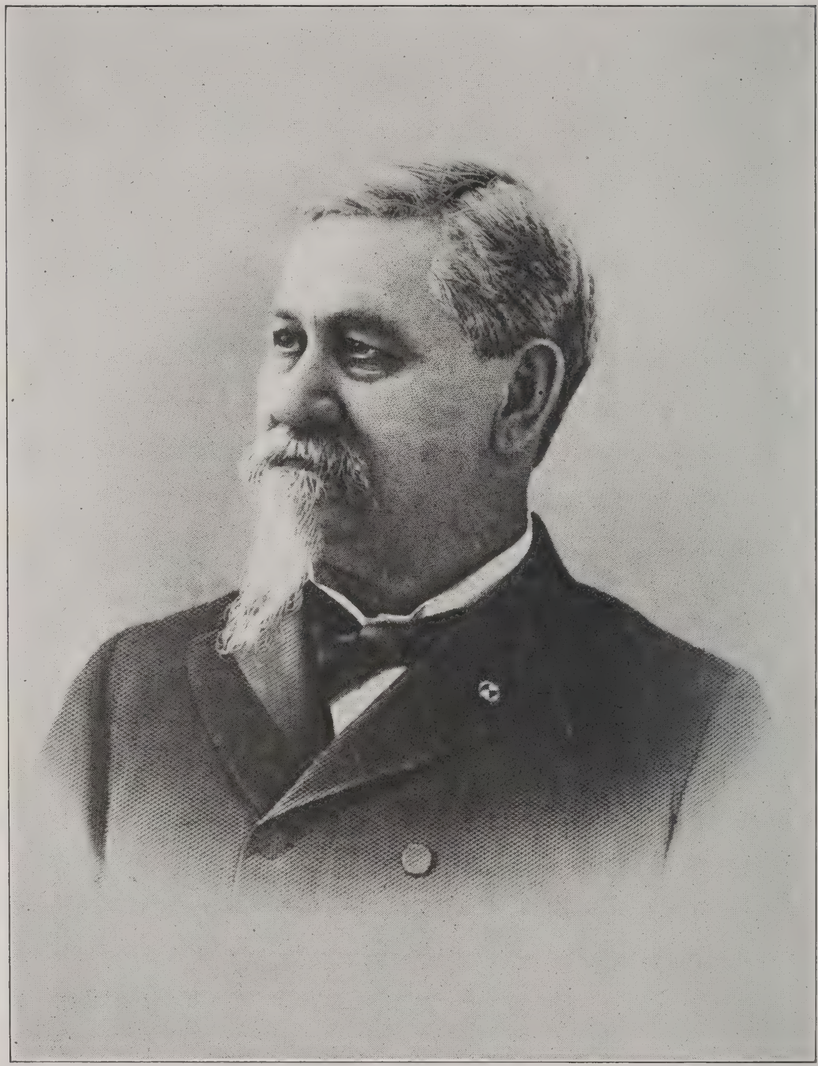
The book opens with a brief history of the discovery of toluene and its nitro-derivatives. The theory of the nitration of toluene and the properties of the mono-, di- and trinitrotoluenes are discussed in technical language. A complete description is given of the manufacture, purification, inspection and testing of TNT. The last two chapters are devoted to the consideration of accidents in TNT plants and to TNT diseases.

This book offers, to readers who have had some scientific training, a clear and very readable account of the chemistry of TNT. Those interested in modern explosives will find it very useful and instructive.

Errata.

In No. 52, on Contents page (iii) for "Construction of Concrete Dam in Hudson River at Troy, N. Y., 1916. By Mr. A. C. Harper, Assistant Engineer," read "Construction of Concrete Dam in Hudson River at Troy, N. Y., 1916, in Charge of Col. W. M. Black, Corps of Engineers. By Maj. M. J. McDonough, Corps of Engineers, and others."

In No. 52, page 437, in title of article after "Construction of Concrete Dam in Hudson River at Troy, N. Y., 1916," read "In Charge of Col. W. M. Black, Corps of Engineers. By Maj. M. J. McDonough, Corps of Engineers, and others."



GEN. ORLANDO M. POE

THE STOKES GUN AND SHELL, AND THEIR DEVELOPMENT[1]

By

Sir Wilfrid Stokes, K.B. E.

It has been with great diffidence that I have undertaken to address you today as the third Gustave Canet Lecturer. The subject which your Council has approved of is one about which, three years ago, I knew practically nothing, nor can I today claim any deep knowledge which justifies me in standing before you and stating that I have solved any great problems hitherto obscure. My only possible justification is that I have been permitted to introduce into modern warfare a weapon of unusual simplicity and lightness which may possibly tend to exert an influence in the direction of checking the tendency to complication and intricacy which, I fear, is the vogue amongst modern expert designers.

The first Canet Lecture, which was delivered by Sir Trevor Dawson in 1909, dealt with "The Engineering of Ordnance," involving designs and methods of manufacture which are the outcome of long years of study and experience. The evolution of ordnance must of necessity depend to a large degree upon the process of trial and error, which naturally leads further and further from primitive simplicity. Cause and effect are not always obvious. Minds become set in one direction, and not inclined to retrace steps which have, perhaps under slightly different conditions, not been fruitful of good results.

I venture therefore to throw out the suggestion that an investigation on "The Engineering of Projectiles and their Components" could be of considerable service to the nation, because nearly all these problems are engineering problems, in the solution of which the practical manufacturing engineer is the most likely person to be helpful, at any rate, from the production point of view.

[1]The Junior Institution of Engineers. Third Gustave Canet Lecture. Delivered on Monday, June 24, 1918. Slightly abridged.

Reprinted from *The Engineer,* London, July 5-12, 1918.

I hesitate to advocate the addition of still one more department to the long list under the Minister of Munitions, but I venture to predict that if a "Simplification of Designs Department" was seriously and properly set to work, its effect, both on the rate and cost of production, would give equal satisfaction to the supply departments and the Chancellor of the Exchequer.

All this you may think has little or no bearing on the subject more particularly before us this evening. My retort, however, is that modern warfare has now developed into one of exhaustion of men and money. Simplicity in design means small cost and quick delivery, not to mention other advantages in the field, and I would therefore ask you to pause, perhaps longer than you otherwise would feel inclined to do, in the consideration of the Stokes gun and shell, as examples of what can be done in one direction, at least, when design is not hampered by precedent or long-established practice.

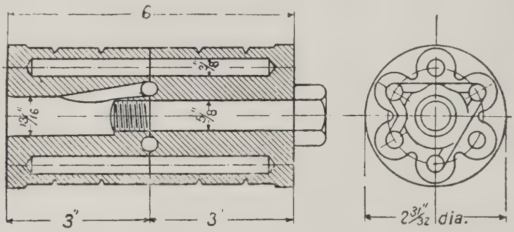


Fig. 1. Original compartment bomb.

THE ORIGINAL CONCEPTION.

The beginning of the present war found us quite unprepared, more particularly in weapons suitable for trench warfare, and many expedients were resorted to by "Our Contemptible Little Army," having for their object the throwing of high explosives a short distance from one trench to another. When my attention was first called to the position there were four service trench howitzer designs in use, all more or less slow, heavy, and difficult to manufacture and use. It was suggested to me that we were badly off for "Frightfulness" at the front, and that our men were not having a fair chance. Could I think of anything?

What I thought of is shown on Figs. 1 and 2, which is reproduced from the information I sent to the War-office through a friend in December, 1914. Stated shortly, the proposal consisted of a cast iron bomb with six compartments containing explosive, with a time-

fuse which was lighted at the moment of firing, and which was so arranged that each of the six compartments exploded at unequal intervals. At each explosion it was intended that the bomb would be blown into a fresh position, and that, therefore, if it fell into a trench it would be very searching and demoralizing. A seventh compartment placed centrally contained a cartridge holding the propellant. The gun, or howitzer, for firing the bombs was a simple tubular barrel with two adjustable legs, thus forming a tripod. The recoil was taken by a cast iron bowl attached to the base of the barrel.

The lower end of the barrel was provided with a pointed central rod for the purpose of firing the propellant cartridge, when the

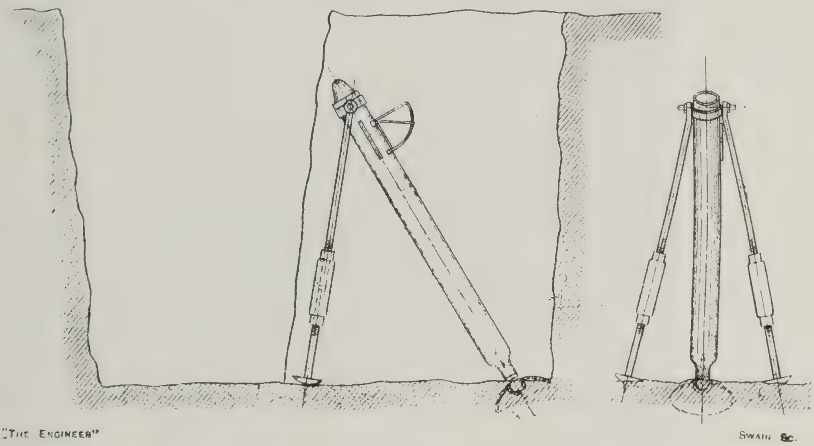


Fig. 2. Original design of Stokes gun.

bomb was allowed to slide down to the bottom of the barrel. The main features of the scheme thus were:—(1) A bomb producing successive explosions. (2) A bomb provided with its necessary charge of propellant ready for firing. (3) A simple gun without moving firing mechanism capable of automatically firing bombs as quickly as they could be fed into the muzzle and allowed to slide down to the spike at the bottom.

From this somewhat sketchy scheme there ultimately emerged the weapon and projectiles which it is my privilege to describe to you this evening, by going through the various stages of evolution which resulted from the experience and knowledge which I gradually acquired.

Looking back at what was done, I am tempted to wonder at

my temerity in proceeding in the face of the attitude taken up by the experts in the subject, who with one accord "turned down" the proposals I put forward. At that time there was no Munitions Inventions Department, and, so far as I know, no machinery for developing schemes put forward in a crude form. The position to-day is very different from what it was in the early part of 1915, and inventors have now much more chance of obtaining a sympathetic hearing.

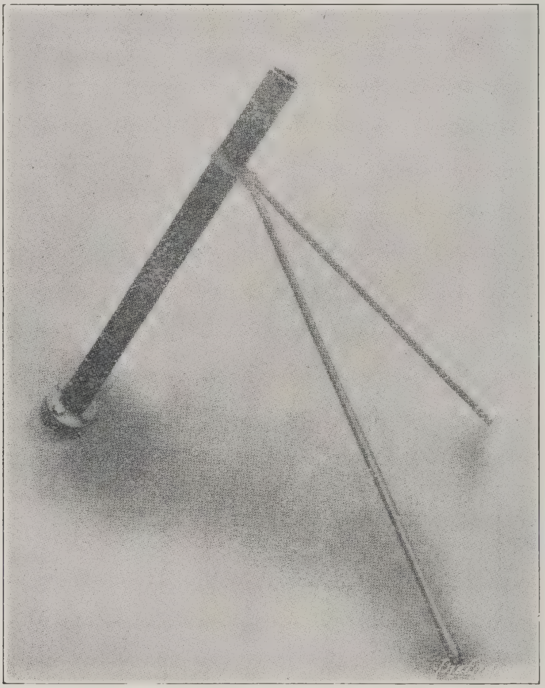


Fig. 3. First gun made.

THE PRIMITIVE GUN.

Acting on the courage of my own convictions, however, I had a primitive gun made at the works of Messrs. Ransomes and Rapier, Ltd., Ipswich, out of a piece of drawn tube, and a shell out of a piece of bar—see Figs. 3 and 4—which gave promising results. In fact, the range so much exceeded my expectations that, much to everyone's surprise, my first shot nearly took refuge in a cottage.

Other demonstrations followed, from which emerged the following conclusions:—(1) The idea of the gun was good, but in

need of development. (2) The bouncing cracker bomb was not so good as a single compartment shell. (3) That my knowledge of propellants was so limited that only black powder gave anything like consistent results. (4) That as a burster, black powder should be used, in view of the shortage of high explosive and the desirability of using a cast iron shell.

Encouraged by the results so far obtained, and animated by a strong desire to do something to help to win the war, I devoted my week-ends to trials of various sorts, so that I might develop the weapon into something which would be acceptable to the authorities.

The problem of the gun itself was not very difficult. I set out with four objects in view:—(1) simplicity in manufacture; (2) simplicity and speed in firing; (3) lightness and portability; (4) quickness and ease in setting up, and change of objective.

The first barrels made were bored tubes, but it was evident that

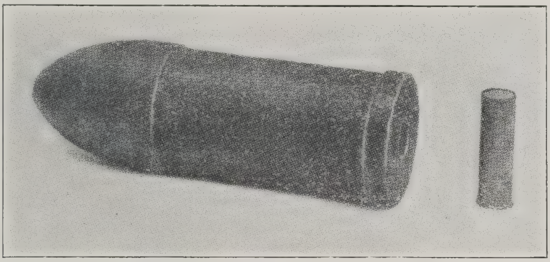


Fig. 4. First solid shell.

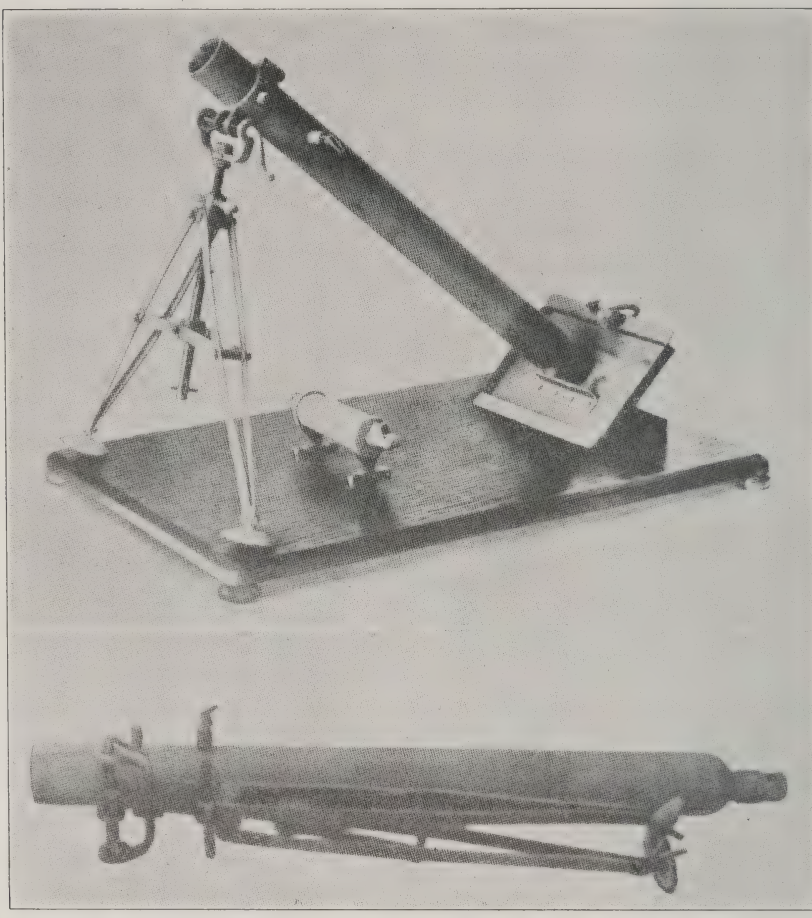
if the tubes could be drawn with sufficient accuracy, boring might be dispensed with. Arrangements were therefore made to cold-draw the barrels, and after some preliminary difficulties had been overcome the results were quite satisfactory, even without heat treatment. The lower end was bottle-necked by plant already used in the manufacture of gas cylinders.

The design of the front legs involved a good deal of thought. Eventually a simple "A" frame was made, capable of folding up when not in use, as shown in Figs. 5 and 6. The elevating and traversing screws were double threaded. The traversing screw engaged with projections formed on a gun-metal collar studded on to the barrel.

This arrangement worked well if the gun was set up with the legs approximately at right angles to the barrel. In service, however, it was found difficult to get the gun set up properly, and to

meet this a modified leg was introduced of heavier design and with only half the traverse—see Fig. 7.

In this design the frame is also arranged to fold up, and to meet the extra weight the legs take apart from the barrel. The



Figs. 5 and 6. First service pattern gun.

traversing screw is hollow, so that a central pin may be inserted through it and the ends of the crutch on the top of the elevating screw. This pin is withdrawn when detaching the legs—see Fig. 8. Another feature is the introduction of bevel gear for operating the elevating nut. The frame is tubular, instead of the flat bar construction in the original design, and the whole scheme is more

on the lines of a machine gun mounting. The very limited traversing range is the principal drawback, and I have since put forward an improvement on simple lines which has four times the lateral range, without adding to the weight. This is made possible by the

Figs. 7 and 8. Second service pattern gun.

introduction of a nest of springs which takes up the shock of discharge, and thus does away with the danger of damage when the gun is badly set up. This design is still under consideration, and I fear I must therefore not give details of it.

The recoil of the gun when fired is taken by a pressed steel base

plate—see Fig. 9—which is set up in the ground as nearly as practicable at right angles to the barrel in its firing position.

In order to increase the traverse, three cup-shaped indentations are provided to receive the base of the barrel in alternative positions. A shelf angle helps to keep the barrel in position when the ground is of an elastic character. A rope handle is used when carrying the base plate.

THE CONSTRUCTION OF THE STOKES GUN.

Returning to the design of the barrel, it will be noted that the base is closed by a cap screwed on to the end, which is externally threaded for the purpose. Into this cap is screwed a short cylindrical rod projecting into the barrel. The upper end of this rod, or striker, is slightly convex, and a small nipple is formed in the

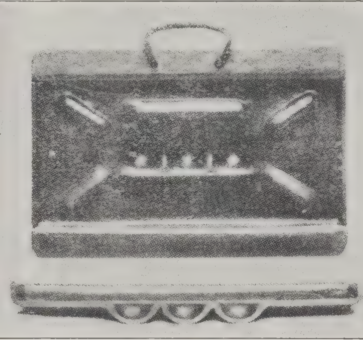


Fig. 9. Pressed steel base plate.

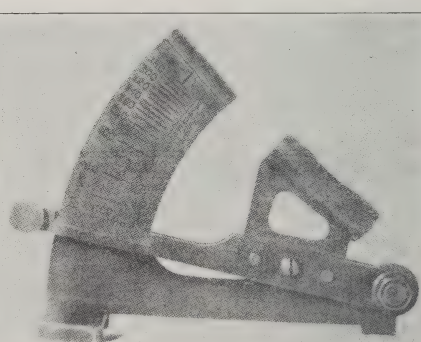


Fig. 10. Clinometer.

centre. As the face of the striker takes the blow of the projectile when it is allowed to slide down the barrel, this nipple fires the cap of the propelling cartridge which is placed at the lower end of the projectile. It will thus be seen that there are no mechanisms or moving parts in the base of the gun, and that the firing is automatic, and simply depends on the energy acquired by the projectile sliding down the barrel. It may be remarked in passing that a trench gun, or howitzer, has a high angle fire, and a projectile will therefore always slide freely down the barrel.

The design of the striker took some time to work out, because I started off on the wrong track. My original idea was that the propellant should be placed in a central cavity in the shell, and that it should blow out the end of the cartridge past a striker having a pointed end. This scheme had two disadvantages. First the fouling of the gun by the residue from the cartridge ends, and

second, the absence of a definite confinement of the propellant which would ensure its burning properly and regularly. When I found out this latter defect I tried a square ended striker in connection with an enclosed cartridge chamber, with the result that I split open a solid steel shell and nearly burst the barrel. This taught me caution, and thereafter I made a rough-and-ready calculation as to likely pressures before firing any fresh arrangement or propellant. It was some time, however, I am ashamed to say, before I arrived at the proper size and shape of the striker nipple, to which I will again refer when dealing with the development of the cartridge container.

The barrel is formed of a cold-drawn steel tube, the thickness being determined by the pressure developed by the propellant near the base. There is a very considerable expansion chamber, which reduces this pressure to only about 1¾ tons per square inch in the case of the 3-inch gun.

This expansion chamber is important, because if ballistite—the propellant adopted—is confined in a chamber which it completely fills, with it a pressure of over 40 tons per square inch is generated. The cubical contents of the expansion chamber in relation to the contents of the cartridge are such that this 40 tons is reduced down to 1¾ tons when acting on the walls of the gun and projectile. A 3-inch barrel was turned down for a length of 2 feet, at a thickness of only one-sixteenth of an inch. This barrel was proofed with 10 rounds of full charge projectiles, and showed no sign of deformation.

A light canvas cap is provided to cover the muzzle when the gun is not in use to keep out rain and dust. In the original guns a bolt was provided near the muzzle, projecting inwards and capable of withdrawal by a lanyard. Thus a projectile could be placed in the gun and fired from a distance by withdrawing the bolt supporting it. This firing from a distance followed the practice of mortars then in use, but a little experience showed the bolt to be not only unnecessary but inconvenient for rapid fire. The present guns, therefore, have no safety bolts, and rapid fire is facilitated. The speed of firing is measured by the skill displayed in dropping the projectile down the gun and in the supply of projectiles being maintained. It is quite easy to fire from 20 to 30 rounds per minute, and I believe a record team has fired off 43 shells per minute. There is no danger of the hand being hit by the projectile.

RANGE VARIATION.

The range variation can be obtained in four ways:—(1) By varying the angle; (2) by varying the propellant charge; (3) by varying the expansion chamber; (4) by providing escape exits for the propellant.

(1) Varying the angle within limits is the simplest. The maximum range is obtained with the barrel at about 45 degrees. To shorten the range, say, 50 per cent, the angle must be increased to about 72 degrees, but at this angle the height of flight may make the effect of wind a seriously disturbing factor on the accuracy.

(2) It is therefore necessary to have resort to varying charges as well as varying angles. I originally contemplated four different charges, but ultimately these were reduced to two for the sake of simplicity.

(3) To vary the expansion chamber involves alteration to the length of the striker. This is not convenient, and after a few attempts was abandoned as impracticable. It was found, however, that there was a striker length which gives the maximum range. Increasing the pressure by shortening the striker did not further increase the range, owing to the greater escape past the projectile, due to the windage.

(4) The last alternative, viz. of providing means for allowing the escape of part of the propellant pressure was also abandoned for several reasons, amongst the most important being:—(*a*) Avoiding unnecessary complications; (*b*) the inconvenience from excessive noise when firing; (*c*) the objection to having openings at the base when firing in water-logged trenches; (*d*) the difficulty of definite and quick control.

In order to provide an easy method of getting on to an objective a simple clinometer was designed. (See Fig. 10.) The arm carrying the bubble gives two sets of readings. On one side the range in yards obtained with the full charge is shown, together with the time of flight for fuse setting, and on the other, similar information in connection with the lesser charge. Latterly, however, owing to the multiplicity of charges and other alterations, range tables have to be used in conjunction with a simple clinometer reading angles only.

In order to enable the gun, when set up in a trench, to be laid on an object, a telescopic periscope was provided to engage with a socket on the collar belonging to the mounting. This socket has its axis parallel to the axis of the barrel. Thus, when the periscope

is vertical—as shown by the spirit bubble—any object visible through the periscope and falling on the center lines is in the direct line of fire. In practice, I understand that sufficient accuracy can be obtained without the use of a periscope.

Having dealt so far with the details of the gun, I will now return to the projectile.

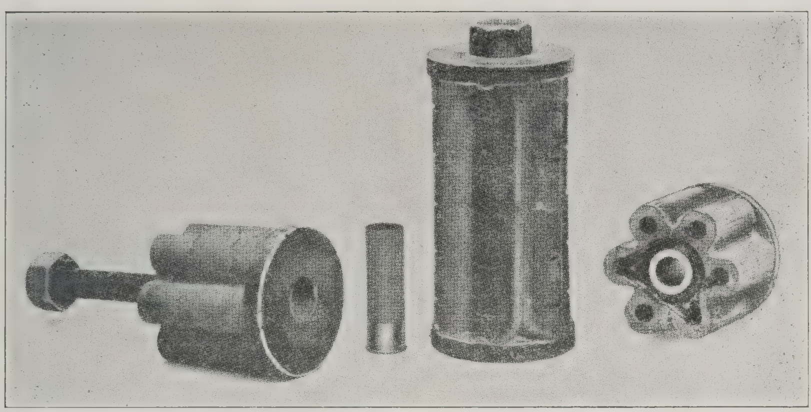


Fig. 11. Original cast-iron shell—dissembled.

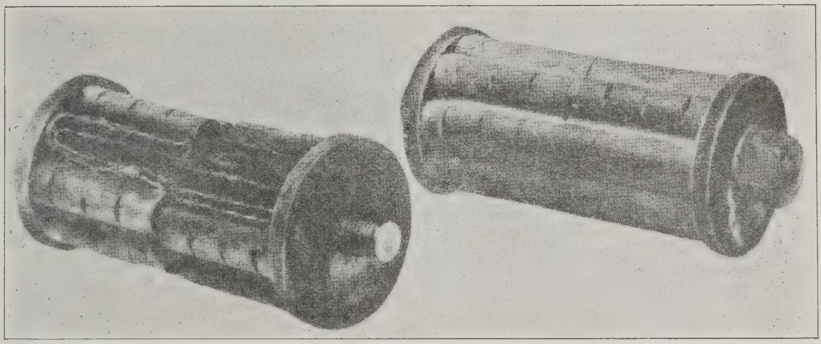


Fig. 12. Original cast-iron shell—two compartments burst open.

It will be remembered that my original idea was to have a projectile formed with a number of chambers holding explosive, which should be arranged to give successive explosions in different positions. The first conception is shown in Figs. 11 and 12. It is formed in two parts, secured by a central bolt and arranged with time fuse connections between the chambers. I very soon found this scheme impracticable, as the first or second explosion opened the joint, and the remaining chambers went off simultaneously.

I next tried a bundle of separate cast iron chambers with external fuses. (See Fig. 13.) This also was a failure, as the violence of the first explosion broke up and fired the rest. By this time I was officially told that the "bouncing" idea was not acceptable. For my own satisfaction, however, I made a final effort, which turned out fairly satisfactory. This device consisted of four concentric chambers holding black powder, and formed by fitting cast iron cylinders one outside the other and so shaped that the ends were closed. (Fig. 14.) A short length of time fuse was attached

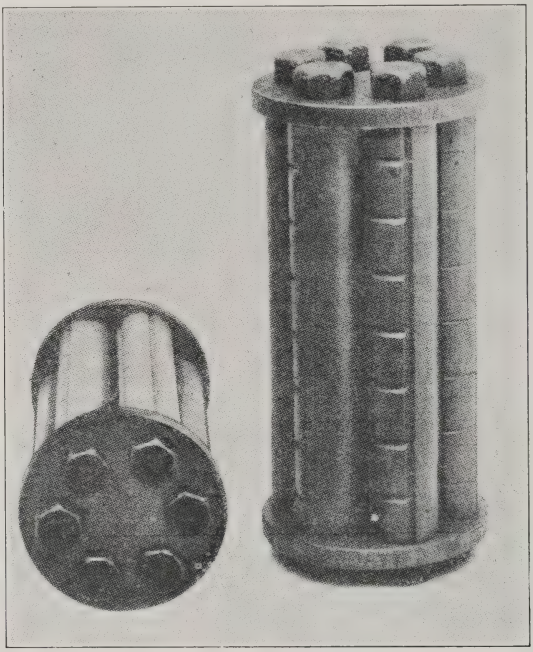


Fig. 13. Cast-iron compound shell with six chambers.

to each chamber of such relative lengths that the explosions took place successively, beginning with the outer chamber and finishing with the center one. This scheme had the desired effect of successive bouncing explosions, but the construction was too complicated and heavy to encourage the attempt to obtain its adoption.

From this time onward I devoted my attention to the production of a shell having sufficient accuracy and a single bursting charge.

As the gun barrel was not rifled, the projectile, when fired, very quickly began to turn over in its flight, and the question arose as to whether or not some arrangement should be made to make it fly end

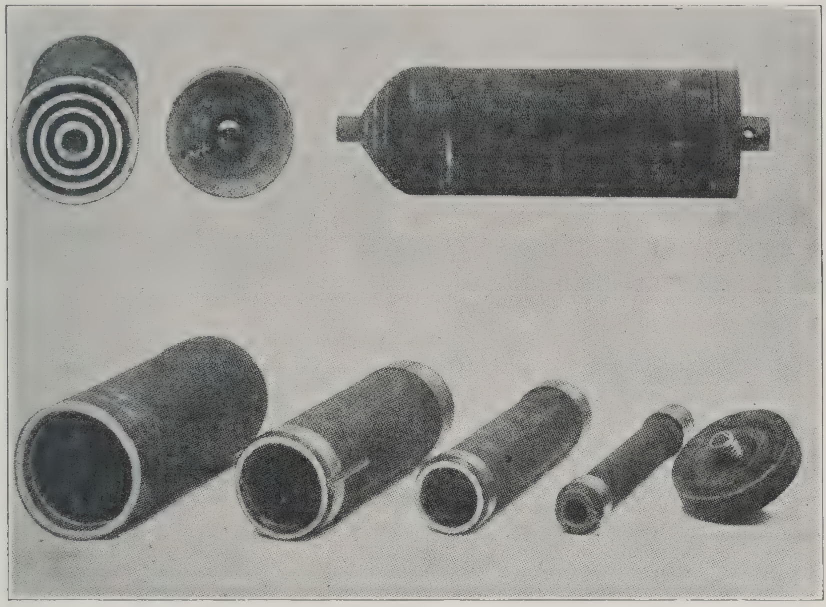


Fig. 14. Cast-iron shell with four concentric compartments.

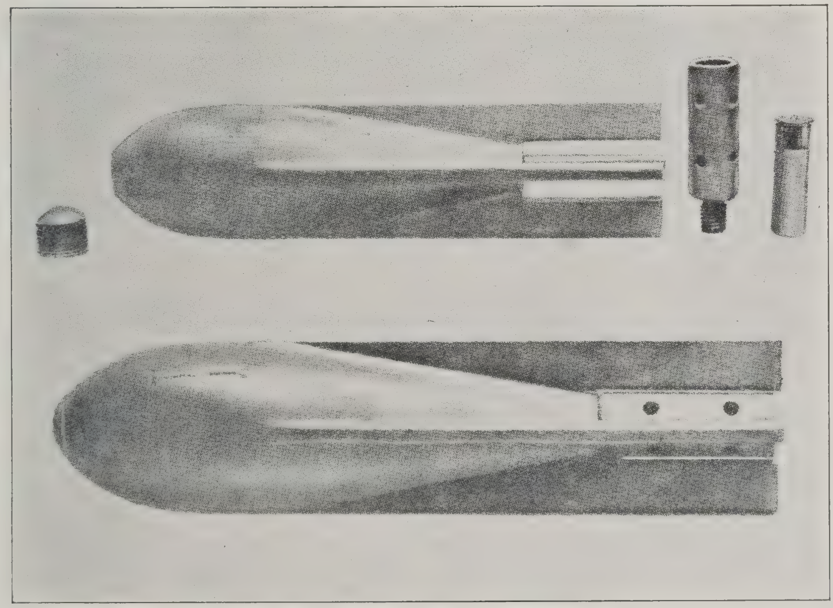


Fig. 15. Cast-iron shell, to fly end-on.

on. Various expedients were tried, but nothing gave such uniform results as the shell shown in Fig. 15, which has a body formed more or less on stream lines, with wings at the tail end. For various reasons, however, this design was not adopted, although latterly there seems to be a movement in the direction of using a cast iron shell with wings.

I next experimented with a simple cylindrical cast iron shell, shown in Fig. 16, which held about 1 pound of black powder, and the fragmentation of which was quite good. This design involves very little machining, and is simple and cheap to make.

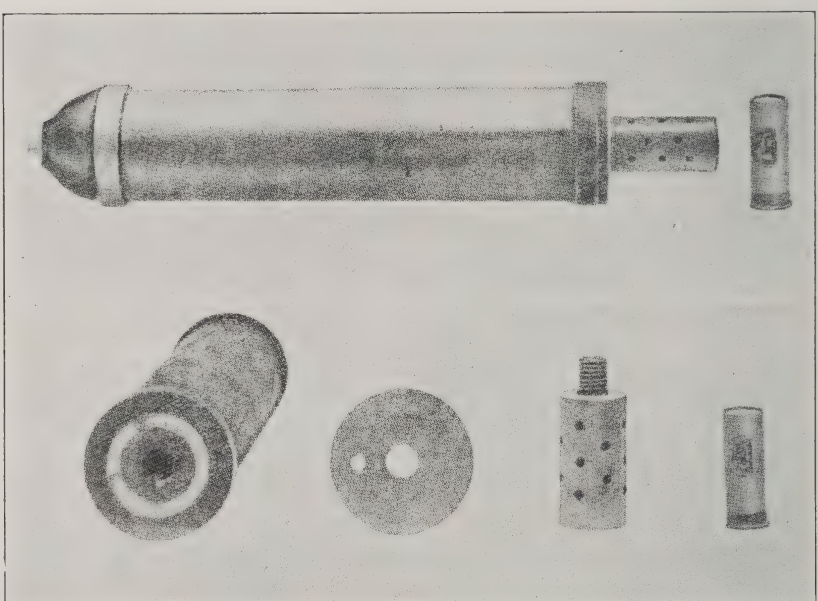


Fig. 16. Cast-iron shell and fuse for black-powder burster.

The final design adopted, however, is shown in Figs. 17 and 18, and consists of a piece of wrought steel tube forming the body, with screwed-in ends, thus giving a very light construction, capable of holding about three times as much high explosive as an 18-pounder service shell. The screwed-in ends have to be machined to fine limits as regards diameter, so that the windage losses may be fairly constant.

When developing these types of shell I was confronted with many difficulties, owing to my previous inexperience. To obtain regularity, or even certainty with the propellant, involved becoming ac-

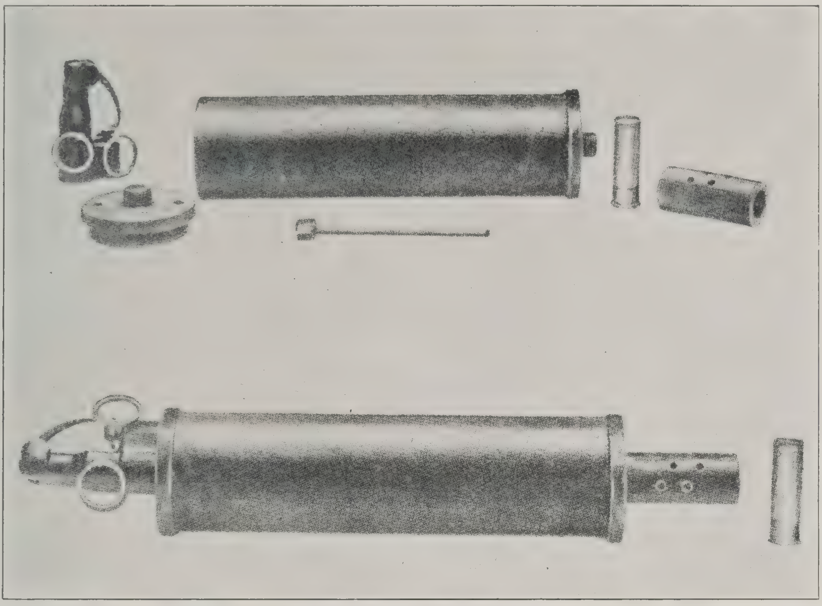


Fig. 17. Service 3-inch H. E. shell and fuse.

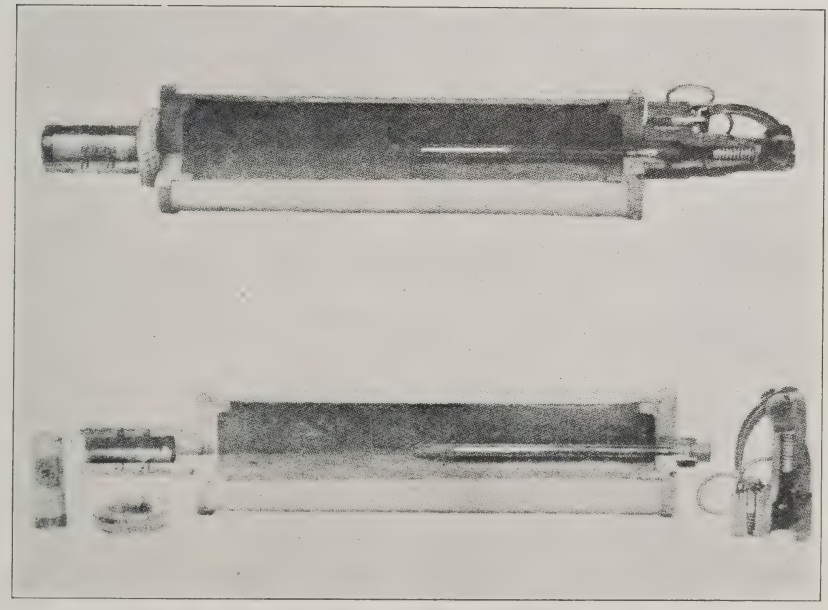


Fig. 18. Sectional view of 3-inch H. E. service shell.

quainted with the fundamental principles, such as, that properly to burn a propellant a definite pressure must be generated.

THE PROPELLANT.

In a shot-gun the propellant is confined by the inertia of the shot in front of it, and being also confined in other directions, the necessary conditions are present for uniform burning. In my case, however, the conditions were different, as, having abandoned the idea of allowing the end of the cartridge to blow out, it became necessary to provide vents in the side walls. Starting with an ordinary sporting cartridge case, I placed it in a tube or "cartridge container," projecting from the base of the projectile, and provided it with holes. The next difficulty was to determine the size, number, and position of these holes which would avoid one or other of the following objections:—(1) Bursting the container; (2) blowing out the end of the cartridge; (3) not igniting the propellant at all, or not with certainty.

It soon became evident that the cartridge container must be made thicker than hydraulic tubing, and that the material used must be of good quality, to avoid splitting open, as the pressure must be at least 2 tons per square inch. The diameter of the holes must be such that before the side of the cartridge case gives way a sufficient pressure is generated to ensure burning the complete charge thoroughly. In addition to the size and number of holes, it was found that the position of the nearest holes to the ignition end had marked effect on the results.

Another difficulty arose from the amount of charge which had to be ignited, and which required a cap with more fulminate of mercury than the normal sporting cartridge cap. This difficulty was at first accentuated by the fact that owing to the wrong shape of the striker nipple, the anvil of the cap was sometimes displaced so as partly to close the flash hole, thus giving short range or miss-fire.

Primers of various sorts and amounts were tried and abandoned.

In the case of the 3-in. gun a No. 12 bore size cartridge is used, and in the 4-in. a No. 4 bore. These cartridges are colored differently, according to the charge they contain, and are varnished so as to make them waterproof. A distinctive mark in the end wad facilitates recognition in the dark, and the end turnover is slightly dented, which ensures a tight fit in the cartridge container, notwithstanding variations in the relative sizes of the cartridges and containers.

Many of the initial difficulties arose from a lack of uniformity in

the results. These variations I ultimately found were due to changes in temperature. In warm weather the cap and propellant are more active. I was just on the border line between success and failure, and I frequently found that defects which I had eliminated one day reappeared the next under colder conditions.

These uneven results were very disconcerting and difficult at first to understand. When deciding upon the best kind of propellant, practically all the available smokeless powders were tried, but Nobel's Sporting Ballistite proved in every way the best for the purpose, and was ultimately adopted. Ballistite is a combination of nitro-glycerine with gun-cotton. It is rolled into thin sheets and cut up into squares and coated with graphite. It is very quick burning, leaves no residue, and gives about 27 yard-pounds range per grain. In common with other propellants, its thickness governs the speed of burning, and some difficulty was at one time experienced on account of the makers departing slightly from their previous practice in this respect, resulting in the cartridge end blowing out. With ballistite there is very little flash at the muzzle of the gun, even with the original full charge. This is doubtless due to the low muzzle pressure.

When experimenting with black powder, I was struck with the small amount of smoke produced, and this I attributed to the large air chamber in which the powder was burnt. The fouling of the gun, however, made black powder unsuitable.

INCREASED RANGE OF GUN.

When the gun was first issued for service, a range of about 430 yards was considered sufficient. Under altered fighting conditions, however, it became desirable to increase the range, and this has been done by adding extra charges, made up in the form of rings, which can be slipped over the outside of the cartridge container. The propellant contained in these rings is somewhat thicker than the ballistite in the cartridge, in order that the rate of burning may be so slow as not to add materially to the initial pressure in the base of the gun. The muzzle pressure, however, is considerably increased, as also the flash. The fabric material from which these rings are made tends to foul the gun, and must also be kept dry. An alternative method, which does away with these disadvantages, has been put forward, and is now under consideration.

In order that the shell may slide with sufficient freedom down the barrel, a windage has to be provided which in the case of the 3-in. gun amounts to 2½-hundredths of an inch. This windage re-

duces the range somewhat, but, as the amount of propellant used is trifling, the loss is not material. Experiments were made using thin flanged copper gas checks attached to the base of the shell, and shaped like a pump leather. It was found that the range was increased by about 30 per cent, but that the accuracy was not improved, probably owing to variations due to the friction set up in the barrel.

THE TIME FUSE.

The next problem which required solving was the best means of bursting the shell by some form of time fuse. I started to work, using a short length of projecting Bickford fuse, which should be cut to the required length and lighted at the moment of firing. Bickford time fuse is commercially used for blasting operations, and is a waterproof flexible construction of various makes, with a black powder core woven with strands of hemp. When lighted it burns like a squib, generally at the rate of about 3/8-in. per second, if the end is free for the escape of the products of combustion.

In the case of the cast iron shell shown in Fig. 16 a Bickford fuse is contained in an annular space formed in the base of the shell. One end of the fuse projects into the powder filling in the shell, and the whole was bedded in plaster of paris. A washer, having a hole in it immediately over the Bickford ring, is capable of rotation when the cartridge container is slightly unscrewed. The edge of this washer is marked in seconds relative to a zero mark on the shell flange. A piercing tool is inserted through the hole in the washer when the desired setting is made, thus cutting through the outer fabric of the Bickford fuse, so that on firing the flash of the propellant lights the fuse at the desired spot. Many experiments were made with this arrangement, and some very good results obtained. No prematures were experienced, and with a black powder burster the fragmentation was excellent.

When, however, high explosive is used, it is necessary to adopt a detonator, and a fresh arrangement is necessary. This consists in providing the nose end of the shell with a thin detonator tube projecting into the high explosive filling, into which the detonator and Bickford fuse can be inserted. The upper end of the Bickford fuse is fixed in a chamber containing a cap, which, on being struck, lights the Bickford, the length of which determines the interval which elapses before the detonator explodes.

It should be noted that detonators are occasionally very sensi-

tive, and every precaution should therefore be taken to avoid a premature.

In the arrangement described, the detonator is fired in the direction which still further tends to compress the fulminate of mercury and not to break it up. This is the only safe way to fire a detonator, and the fact that it is crimped on to the Bickford fuse, which is the elastic member which starts it in motion when fired, still further adds to the safety.

The method of firing the cap which lights the fuse is shown in

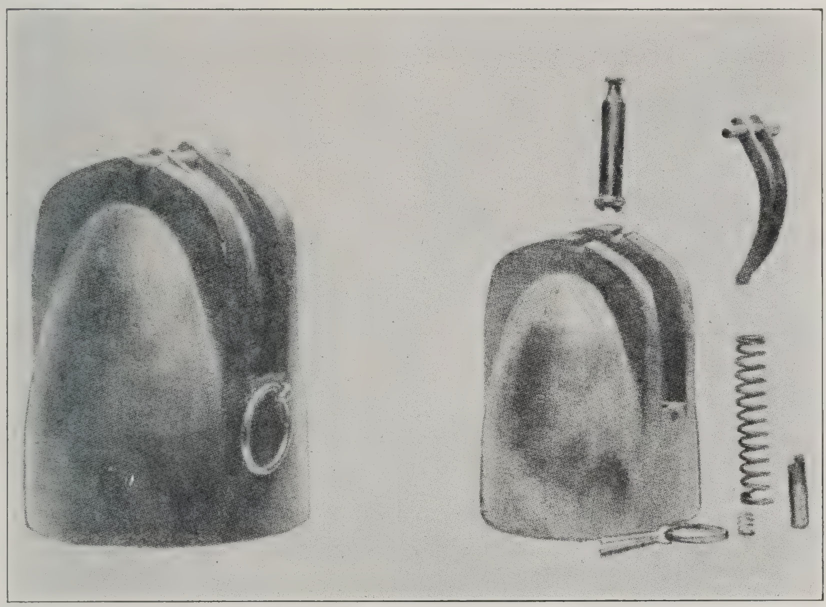


Fig. 19. First time-fuse head.

Figs. 19 to 22, which show the development of the type of fuse heads.

Fig. 19 shows one of the first heads made, while Fig. 20 shows an improved arrangement.

The mechanism is very similar to that of the Mills hand grenade, viz, a central bolt with a pent up spiral spring coiled round it. The central bolt is maintained in the firing position by a lever which, when uncontrolled, flies outwards and releases the central bolt. The end of this lever, however, is maintained in its proper position by a set-back bolt, which, in turn, is kept in position by a coiled spring beneath it. A safety-pin is arranged so that the set-back bolt cannot be displaced and the lever released until the pin is withdrawn. On firing, the inertia of the set-back bolt compresses the spring behind

it sufficiently to allow the lever to be released, which then flies off, allowing the central bolt to strike the cap at the end of the Bickford fuse, which is thus lighted.

Fig. 21 shows the service pattern as issued. The mechanism is precisely the same, but the fly-off lever is exposed instead of being shrouded by the body of the fuse, and is therefore liable to be knocked off with rough usage.

Fig. 22 shows a better arrangement, in which a pent-up spring is dispensed with, as also the fly-off lever. It was, however, never

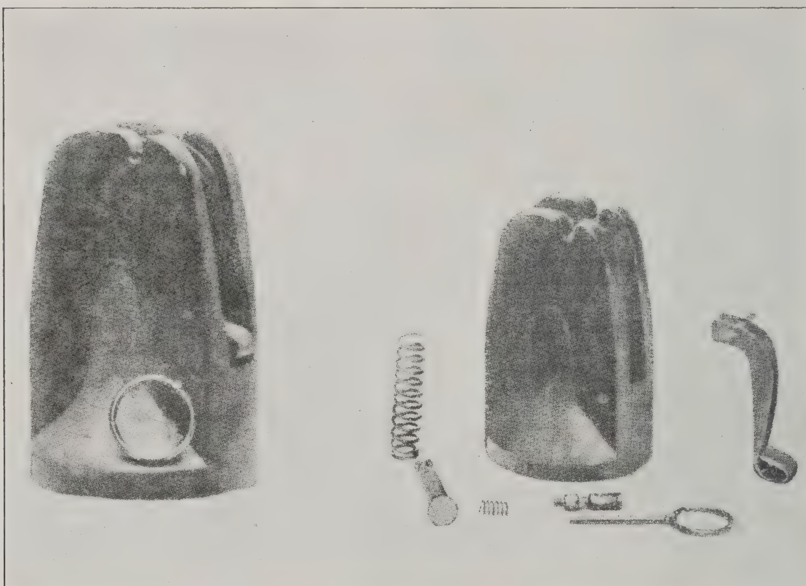


Fig. 20. Second time-fuse head.

adopted, as the design shown on Fig. 21 had already been put in hand. A safety pin passes through the head, and, until it is withdrawn, prevents the central bolt striking the fuse cap or the shell sliding down the gun.

The coil spring round the central bolt is of such strength that on firing, the inertia of the central bolt is sufficient to cause it, by compressing the spring, to strike the fuse cap. In the case of a partial miss-fire the shock of discharge is not sufficient to compress the spring, and the cap is therefore not struck. Rough usage in one direction only would tend to ignite the cap, and the strength of the spring is such as to cover all reasonable risks.

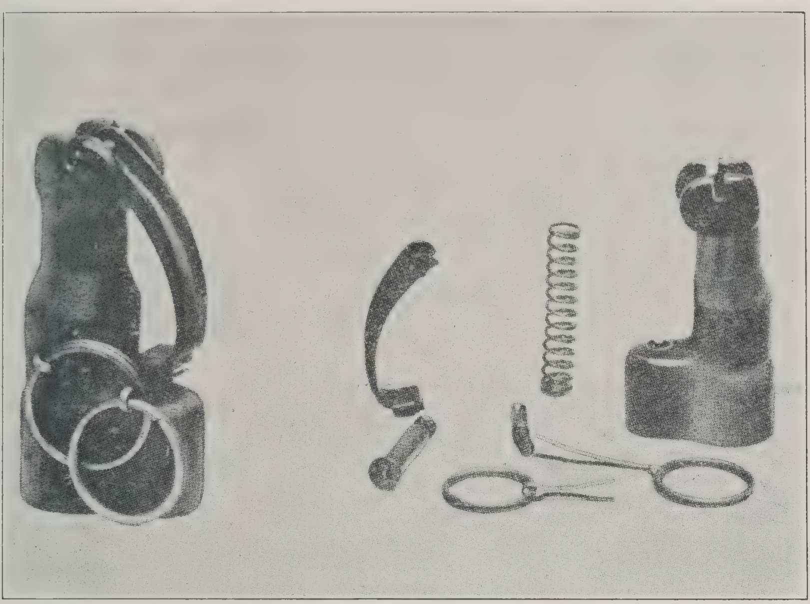


Fig. 21. Service time-fuse head.

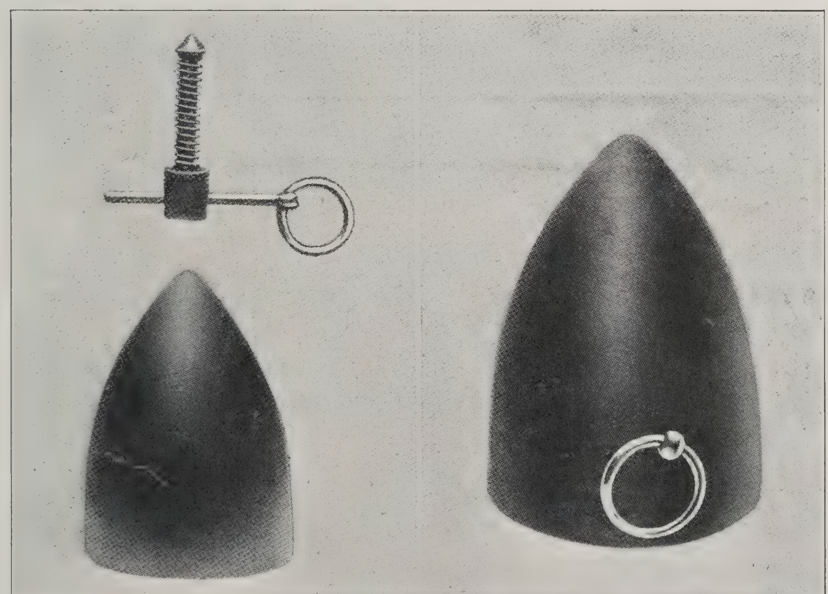


Fig. 22. Final time-fuse head—not adopted.

There are certain difficulties with the use of the Bickford fuse. one of them being the uncertainty of lighting it by means of the fuse cap, more particularly if damp. This can be got over by coating the end of the fuse with fine black powder, applied with a celluloid solution, such as collodion. In order that the best results may be obtained from the Bickford fuse, a free outlet or vent should be provided for the escape of the products of combustion. The fuse should not be bent about before use, otherwise its speed of burning is increased. The crimping both at the detonator and cap end should be carefully carried out in order not to restrict the outlet of the gases. On the other hand, the crimping should be effectively

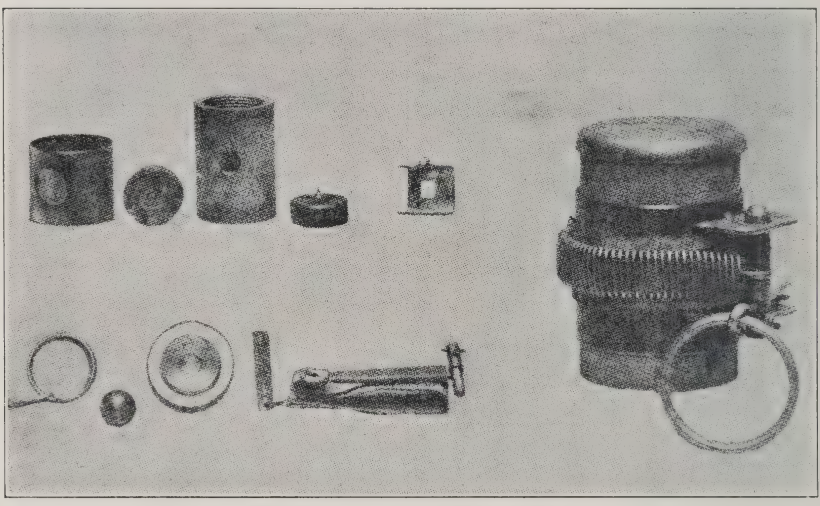


Fig. 23. The ''Allways'' fuse.

done in order that the necessary adhesion may be provided between the parts to be set in motion at the moment of firing.

PERCUSSION FUSE.

Another form of fuse, called the ''Allways'' fuse, is shown on Fig. 23. This is a percussion fuse, and therefore requires no time setting. The construction of the fuse includes a metal ball confined in a chamber having double conical walls, one wall being formed by a movable member carrying a needle point, which can pierce the detonator or cap, which lights an instantaneous fuse or powder puff in connection with the main detonator, which sets off the high explosive charge. A safety device only allows the ball to function after the projectile has been fired from the gun. As its name im-

plies, this fuse operates when the shell reaches the ground, whatever the position of the shell may be. This fuse was originated by the authorities to obviate the trouble of preparing different lengths of time fuse, and has been recently considerably improved.

At the present moment there are three sizes of Stokes guns, with their appropriate ammunition, in use, viz, 3¼-in., 4¼-in. and 6-in. Fig. 24 shows a 2-in. gun, with a self-contained base arrangement for taking the recoil, which, being hemispherical, facilitates variation in the direction of the barrel without readjustment in the ground. This gun would readily fire 4-lb. projectiles a distance of 200 to 300 yards, and should form a very handy weapon for attack.

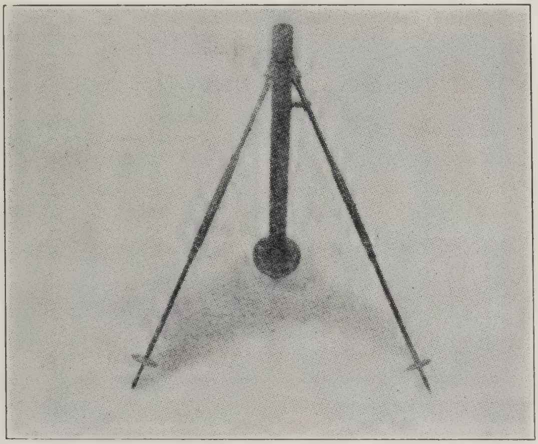


Fig. 24. Two-inch gun, with self-contained base.

The gun was never adopted, but I thought it of sufficient interest to refer to. The 3¼-in. gun fires a high explosive projectile weighing 10¾ lbs. to a maximum range of 800 yards. The 4¼-in. gun is mostly used for smoke and gas shells of various sizes and weights, the maximum range being 1,060 yards with a 26-lb. shell. The 6-in. gun fires 47-lb. high explosive projectiles, the maximum range being 1,420 yards. The shell is of cast iron, with wrought tail wings.

. . . .

Having now described the various stages which were passed through when developing the gun and its projectiles, I venture to hope that the history has not been altogether uninteresting. The weapon, as it is now used, seems, in the light of present knowledge, very simple and obvious, but, like most simple things, the arrival at the final stage involved much patient effort, which was rendered

more difficult by the apparent lack of data to work upon. It is, however, consoling to know that, in the end, facilities have been provided to our armies and those of our Allies at the Front, by means of which, with a comparatively short training and experience, results may be obtained which hitherto were not possible.

This result is largely due to the interest taken in my efforts by certain officers, and also to the facilities and support placed at my disposal by Messrs. Ransomes and Rapier, Ltd., Ipswich, who made all the experimental material used. I welcome this opportunity of thanking all those who have helped me to a successful issue.

OLD AND NEW OPINIONS ABOUT THE VALUE OF PERMANENT AND FORTIFIED POSITIONS.[1]

(*Continued from No. 53.*)

VI.

It would be well if we could show in detail how far in practice theory has been met half way, and its teachings adopted, and to determine to what extent in the history of war they have been approved or rejected. As a matter of fact such an investigation is not so simple as it might appear, and a thorough presentation would demand much greater space than the limits of this article would permit. In the main we must content ourselves with references to what may be found scattered here and there through the body of this writing. We would dwell particularly upon the development of land defences in Switzerland, even at the risk of sometimes repeating ourselves. And even here there must not be expected a sharply defined historical growth, but we will have to take it as it is after being threshed out in our legislative councils, the propositions made, the plans or system eventually determined on. And therein it will appear how far the teachings already reviewed and discussed have been approved and adopted.

When in the eighties of the last century the question of land fortification had begun to assume a position of greater importance, and the discussion of military problems was largely the order of the day, by no means the least of the matters considered was the elaboration of the French system of fortresses, which system had indeed been the provoking cause of these discussions. One of the pamphlets appearing at that time, whose author was Captain Perret, of the General Staff, was published under the auspices of the Neuchatel Officers' Association. Its title was "Swiss Neutrality and the New French Forts." It called especial attention to the French works erected on our western boundary in the following words:

"Our western and southwestern boundaries touch France for

[1] From *Schweizerische Zeitschrift für Artillerie und Genie,* October, November, 1917. Translated from the German by Maj. Henry Swift, Chaplain, U. S. Army, ret.

a stretch of 250 kilometers. Along this line considerable changes have taken place in recent years: indeed we may call it our most mutable frontier. Several new highways and nine railroads have been constructed in that region. This section is now traversed by fifteen highways, while nine railroads either cross it or follow it. The new roads that are perpendicular to our border branch off from two great trunk lines namely—the Belfort-Besancon-Lons-Le Saunier-Bourg-Grenoble line, and that of Dijon-Lyons-Grenoble.

"In the year 1875 the inhabitants of the Pruntruter district waked up one fine morning, and discovered that the east end of the Lomont was to be fortified, that plans and specifications, at least for the inception of these works, were already in the making. There were some searchings of heart, but it was thought that after all they were possibly nothing more than studies; and yet in the year 1876 the foundations were being laid, and in 1877 the batteries of Lomont from Pruntrut could be descried; and then apprehension took on a more acute form, and Swiss and other foreign papers began freely to express their opinions in numerous articles.

"It is not to be disputed but that considerable changes have been effected on our western and southwestern frontier, whose consequences in the time to come we must regard with equanimity, not allowing ourselves to be harping forever on conditions as they formerly existed."

Taking then the stand that the French works on our western frontier, the old as well as those more recently constructed, have more an offensive than a defensive character, the pamphlet concludes as follows:

"The balance cannot be restored otherwise than by an increase in our military strength. We cannot multiply our forces, we must then have recourse to fortifications, whose establishment would urgently demand permanent and effective garrisons, in order that provision could be made for defence over the widest possible area."

The writer fails to indicate what the character of this defensive system should be. Still it is to be inferred that it would resemble the system adopted by the French, consisting of a chain of border forts and batteries. At the very lowest estimate the expense would be or exceed twelve millions, apropos of which the writer says:

"Have we not expended more than a billion on our railroads,

and shall we balk at this further outlay of twelve millions needed to protect the same roads? Shall a country, whose taxable assessment exceeds a billion be deemed too poor to be able to appropriate twelve millions for its defence? Our warlike ancestors were also poor. They built no railroads; but they were wise enough to block the approaches to their country by fortresses. They had no industrial centers as we have today, whose productions amount to eighty millions a year; nowhere on their mountain slopes had they, as now, their herds of cattle, totalling five hundred millions in value; there was no income of thirty-five millions from cheese alone; nor was the country visited in those days, as it is now, by two hundred thousand tourists, who leave behind them more than fifty million francs; and yet, nevertheless, they never failed to fortify and put in a state of defence their chief cities.''

This brochure is typical of the whole flood of pamphlets which appeared at that time, and it may be well to dwell upon them at somewhat greater length. In the first place there was always the contention that we as a state were indisputably justified in erecting a line of fortifications, surely an unnecessary undertaking, and yet, considering what a moot question neutrality was at the time, it was imminently characteristic. In the next place there was seldom any definite scheme proposed for fortification, the articles being content in the main with the sketchiest outlines. In the third place the question of expense was always to the fore, the argument being that even were the outlay necessary considerable, it was within the resources and capacity of the State to meet it. Then there would always come an appeal to the Swiss spirit of self-sacrifice, and a recalling of the martial traditions of their ancestors. Such a method of treatment gives the whole subject a paltry cast, leaving untouched from start to finish the true issues, considerations which are vital for any broad and comprehensive grasp of the great problem of land defence.

In another brief pamphlet entitled ''The German-French Frontier Defences and the Problem of Land Defence,'' the financial side, or—as the writer terms it—the business proposition is dwelt on with special insistence.

''The attempt on the part of our neighbors to inflict injury upon us might eventuate at any time in the blowing up of our tunnels and bridges; and their repair or reconstruction would cost a good deal more than the works which would be needed to prevent

the occurrence of such a catastrophe. And then what profits and earnings might follow on the inauguration of these defensive works so much needed, especially right now in the present depressed condition of our industries, and with so many hands lying idle; a boom which for several years to come would materially enhance the prosperity of the country. What a well-guarded neutrality is worth when contiguous to war activities was shown by our experience in 1866 and in the war of 1870-71. There was a wonderful increase in business, and in every craft and trade. Our neighbors were at war, and the maintenance of their national honor was at the cost of great sacrifices, while on the other hand the neutral attitude maintained by us not only did not injure us in the least, but on the contrary netted us many millions. It was quite a different case during the French invasion of 1796; for the drain on our national resources footed up to some fifteen hundred millions.

"Where and how will a country find credit and support in time of need, whose entire wealth is liable to be swept away by the first surge of the tidal wave of war in its vicinity?

"We deplore the necessity for insisting so strongly on the business aspects of the problem, when the honor and independence of the country are at stake; but—we know for sure our Pappenheimer—

"There are two mental tendencies that touch to the very marrow the disposition to make patriotic sacrifices, which tend to foster an indolence of mind in the facing of every peril liable to be apprehended. There is, in the first place, a silly Chauvinism voiced often in after-dinner speeches, which expresses itself in some such manner as this: Our mountains are our fortresses. Our heroic ancestors have whipped the enemy one against five, and we can do it again.

"Then again there is a thoughtless pessimism, which figures out its estimates of enormous expenditures, in terms about which it is crassly ignorant, and counts it the height of good statesmanship to be forever harping upon the impotency and insolvency of the Federation.

"The first should reflect that a mountain range on the frontier of any neighboring dominion is theirs as much as ours, is for the one who understands best how to take advantage of it, and above all in its utilization avails himself of all the resources of the art of engineering, and does so at the right time. And it is for him to

remember that our forefathers were superior to their adversaries in discipline and military training, which could hardly be asserted of ourselves as compared with any of the great military powers contiguous, who might possibly become our adversaries.

"We suggest to the pessimist this thought, That the question is not whether one of our formidable neighbors would generously allow us time and leisure undisturbed, until he is ready to butcher us, awaiting his opportunity tranquilly, as if the rest of the world were blockheads; but the real proposition is that our submissiveness would involve vastly greater sacrifices than any advantage resulting from such a policy would be worth. We could, if we were so disposed, have the proper degree of strength to defend our country. If we are not willing to take proper measures therefor, then fate has laid up for us that which we shall have well deserved.

"Finally, we may bid the champions of financial stability to lay this well to heart, That it will be too late at the last moment to open the purse-strings of our beloved 'unlimited credit' in order to shift the responsibility upon the shoulders of those who, when the time was ripe, and when the means lay ready to hand, refused to handle the problem of defence.

"Objections, which may be urged from other countries, for fear of political consequences, should never be listened to by the representatives of a free people. It does not comport with the dignity and honor of an independent state that there should even be the possibility of a foreign power mixing up in our internal affairs. The thought should not be tolerated for an instant.

"At all events, do not let us have the soldiery of our confederation, who in the hour of danger are called away from home and herd to defend our borders,—do not let them be forced to confront an adversary superior to themselves in number and training, and on a field that has not been beforehand prepared for any and every contingency."

We have dwelt longer on this publication, perhaps, than many of our readers might deem necessary. But we have done so for this reason, because it appeared to be eminently characteristic of that period, in which the conviction of the urgent need for a fortified frontier had come to assert itself strongly. It shows furthermore that this conviction had been initially forced upon us by the action of the French in erecting fortifications on our western frontier. It shows also what strong measures and forceful arguments

were employed in order to deepen this conviction, and to promote a wide dissemination, until it finally came to be the sentiment, if not of all, still of the majority of the Swiss. And in the pamphlet quoted is to be found the tenor of the greater portion of the land-defence literature, which in the last quarter of the nineteenth century flowed so abundantly from the press. In every event there must be a propaganda of the idea, it had to be popularized, its way had to be smoothed and prepared, so that when the question came before the powers that were for its final decision it could no longer be blocked or tabled by any opposition deserving the name. Had there not been this preparation, then the motion of the Argovian national councillor, Ryniker, for an immediate consideration of the question of land defence would not have met the cordial reception, which it in fact received. Therefore the lack of definite propositions, so prevalent in most of the pamphlets that had appeared, may—as things turned out—be entirely excused.

Moreover, there was soon no lack of motions. That in the very start these all looked toward France, and that the demand was for a system of defences on the western border, was to be expected; for the whole movement had received its start and impetus from the French activities in fortifying that frontier. It is no wonder that the methods adopted were in part patterned from those of our neighbor, and that the demand was for a line of border forts and batteries for the protection of our western front, a line covering all communications with France.

Then one motion followed another, various systems being proposed, according to which it would not suffice to erect a series of barricades on the western boundary, but the necessity was felt for the construction of a central stronghold, located after an exhaustive discussion either at Bern, Zurich or Lucerne. Then the current set another way, and a disposition was manifested to give the whole defensive system a more neutral coloring, to mitigate somewhat the rancorous spirit that would seem to make France the target of every resolution. Other propositions were in the direction of economy, of minimizing the outlay as much as possible, completing only a portion of the defences and deferring a more thorough elaboration until the actual emergency should arise.

It will be remembered that Bernhardi had anticipated just this spirit, when he uttered his warning against the futility of all half-measures. Such was the character of the measures that sought to reduce the cost, made by those who were keen to devise such a

system, that the appropriations could be reduced to the lowest figure. As representative of such ideas there appeared in 1882 an anonymous publication entitled "The Defences of Western Switzerland," upon which, as being a good example of the kind, we will dwell at some length.

While the article discusses in detail the importance of Basle, Geneva, the Venoge-Orbe line, the Jura, the Aar, the High Plateau, Bern from a political, military, and engineering point of view, the conclusions arrived at are set forth in the following résumé:

I. The magnificent works recently constructed at Zurich cover directly or indirectly the whole of Switzerland, and at the same time would serve to check and hinder any attempt on the part of the enemy to make a march by force of arms through the country.

II. Basle is directly protected by Zurich and the defences of the Jura, and needs neither fortifications nor garrisoning.

III. The Jura can be defended by the young Landsturm, with the aid of an auxiliary division and hastily thrown-up works, and needs only a few block-houses, which should be erected in time of peace.

IV. The Venoge-Orbe line should be protected by two permanent and two provisional works, these of considerable proportions, the former at Ecublens and La Sarras, the latter at Echallens and Pomy, these to be completed when needed by hastily thrown-up lines, and defended by detailed troops.

V. Geneva can not be fortified, and therefore needs no garrison. It is indirectly covered by the Venoge-Orbe defences.

VI. The Aar and the Rhine can easily be defended on the North and West by temporary fortifications manned by details of troops.

VII. The High Plateau is to be defended in similar manner by intrenchments.

VIII. The fortifying of Bern can for the time being be deferred. Eventually, after the newly established works at Zurich shall have been completed, temporary fortifications might be erected; and then—if the need appears—two permanent forts might be built, and six others of rubble work might be constructed during time of peace.

IX. The whole defence system of Switzerland would thus con-

> sist of the permanent fortress at Zurich, of two permanent forts on the Venoge line, of two other works of rubble on the Venoge built in time of peace, and of a few wooden block-houses in the Jura.

This scheme has beyond a doubt just that half-measure quality, against which Bernhardi so impressively warns us. On the other hand he has pointed out that, as far as the Swiss defensive system is concerned, to barricade every available approach with a fortification would hardly be practicable; and in every essential the system would be found lacking in case, for instance, a body of troops in time of war should undertake to march through the country: for then things would come to an extremity, and any temporary advantage gained by previous economies would bear no proportion whatever to the time and means that would then have to be prodigally expended.

The credit of having put this view-point in its strongest light must be given to Chief of Division[1] Rothplatz in his strategical essay, "The System of Land Fortification," which appeared in 1880, in which the whole question is systematically and thoroughly treated.

His final summing-up of the various views under discussion is as follows:

(*a*) Any war, while it may be a menace to our neutrality, need not as to its issues be of any immediate concern to Switzerland. The only reason for apprehension is because highways of vital importance for military operations traverse our country.

(*b*) Whatever state is tempted to infringe our neutrality would in fact rather have Switzerland for a friend than as an enemy. And yet the occupation of Switzerland, or a portion thereof, as a base for operations, or as a shield against the same, might appear to the states involved of so much greater advantage that the thought that such a course might array us as enemies would be regarded as an evil of minor importance.

(*c*) We Switzers propose, as long as it is possible, to maintain a neutral attitude; but at the same time we also propose to fend off all warlike operations from our territory.

This is to be accomplished in the simplest and least costly way by our standing off any attempt on the part of foreign forces to

[1]Oberstdivisionär: The highest military title in the Swiss army of that time was Colonel or Oberst, which served as a definitive for titles or higher commands; in such case better rendered by "Chief."—S.

penetrate our frontiers. Such encroachment may be prevented, if by means of fortresses across the plateau we bar their passage along our important strategical highways, which, as long as they lie undefended, would afford an easy access to our territory.

If these highways are effectively blocked, then it would not be to the interest of any state to invade our country: for they could not reach their goal, whose attainment would be the only motive for such intrusion. By means of our fortresses, by means of our barriers wherewith we would block the way, their communications would be imperiled, and a march through would become practically impossible, while an attempt to break through the lines would take too much time, and would in no way be helpful toward the main issue, where the opposing forces would have ample time to make all necessary dispositions against their adversaries.

Here then we find the truest system of a neutral defensive, a system which not only regards the west, but makes front on every side. "The endeavor to maintain our political isolation and independence must be by means of works that will dominate the approach from every side, and of whatever character; not only on the frontier, but including also the internal portions. The system should provide for every possible event. It would embrace the whole of Switzerland, and not be fettered by any one theory, or confined to one point of view."

How well the matter was thought out, both in its military and political aspects, is best shown by what has occurred in the present war; and we not only hold up for example our own system of defence but instance also the experience of Belgium. Although everything has been said in praise of the Gotthard-St. Maurice fortifications, that they present a formidable front in every direction, still the fact is patent that in case of hostilities their main protective efficacy is against the south; and this has necessitated the erection of a group of defences at Murten and on the Hauenstein, furnishing a more direct protection than any permanent works in the heart of the highlands.

The German invasion of Belgium resulted disastrously to the latter country because the defences on the northern frontier of France did not offer the same degree of protection as do those that lie on her eastern border. Assuredly any state, whose neutrality is guaranteed, has a free hand in buttressing the same by the liberal disposition of some system of fortifications of a permanent char-

acter. It will be of no use, however, to organize such a system on one side only, or to make provision alone against some special anticipated emergency. Everything must be expected in distrust of the sincerity of neighboring powers; a more or less unjust policy on their part is to be counted on: for as critical military complications arise, but scant respect will be accorded to conditions as they exist. The present war has assuredly afforded us sufficient illustrations of the same.

Starting from these premises the author of "Systems of Land Defence," in conjunction with the then Chief of Staff, Colonel Siegfried, has elaborated a scheme of fortifications, which embrace two central regions, consisting of a chain of forts of some 200 isolated works, 30 of which pertain to the highlands and 170 to the plateaus. He calls the entire combination a peripheral (*peripherische*) system, which he explains after this manner:

"The peripheral system is based upon the assumption that any war contiguous to the country directly concerns Switzerland, threatening from the frontier an invasion of the interior, to the very heart of the Confederation. In order to prevent this all of the outer circle that has a military value would be fortified, and after that an inner circle, approximately parallel to the other, would be tactically regarded as embraced in one general system of defence.

"And so we maintain that there should be:

"Starting from the interior in the inner circle the two central fortresses;

"In the second circle would be comprised the Venoge line, Jolimont, the line of the inner Jura (Rochefort, Reuchenette, Balsthal, etc.), which would touch the inner circle at Brugg, the line of the Thur, etc.

"The third circle, or outermost ring, would embrace the environs of Geneva, Basle, Schaffhausen, the valley of the Rhine as far as Trübbach.

"The several fronts of the system are determinable by a radius in the directions where inroads are to be apprehended."

But this peripheral system, which he also designates as a "Fortress System of Strong Positions," because it would necessitate the inauguration of a military policy only within the capacity of some great power, has this capital defect, that because of its cost it would be impracticable.

"This system, if carried out completely, is brought up against a

dead wall: for this insurmountable obstacle presents itself, that although based upon the aspirations of a patriotic people, yet the available resources of the nation were not equal to it. On the other hand, no trimming down or simplification of the scheme as proposed would be of any practical value. The system must be a coherent whole, elaborated as it has been by the best military talent of the land, being designed to place Switzerland in an entirely independent position in the event of any war whatever. Any reduction in its scope would be tantamount to the abandonment of the basic principle,—and so we find that the ultimate outcome of the proposition is to draw a chain of border forts about our frontier, so that our mobilization may be accomplished without causing any disturbance.''

Against the latter—the cordon system—the writer expresses himself with acerbity: ''The expression 'cordon system,' in view of the experience afforded us by the history of war, has come to have an evil name; and indeed to such an extent that the mere mention of it is a sufficient demonstration of the disfavor in which the system is held.''

He then comments on the cordon system of Swiss defence as developed, with its numerous auxiliary works pertaining to a group of some eighty forts on the exterior line: ''These forts must all have their permanent garrisons, if we propose to hold them for our own benefit and not for that of a crafty and resourceful enemy.'' The strength of such garrisons would vary according to the size and importance of the fort, ranging from a company to a battalion of infantry for each, not to speak of their necessary complements of artillery and engineers; of which force, of course, a certain portion of the personnel might be granted furloughs in time of profound peace. The proposition ''When danger threatens to mobilize the landwehr of the vicinity, thus manning the works and providing for their defence,'' he regards as from a military standpoint a delusive dream. ''Where would be found, then, the essential conditions of command, where the proper discipline of a garrison made up of such hastily gathered forces? Why, they would hardly know where to find the keys of the gates of the magazine, which perchance have been intrusted to the care of some official in one of the neighboring villages. No, a work which has cost us many a hundred thousand may not be safely confided to an unorganized and hastily assembled mob of landwehr: and so, no matter what difficulties may present themselves, it is absolutely essential that, with such a cordon system, the forts should be held by permanent garrisons pertaining to a regular establishment.''

How just, in this connection, the judgment of the writer has been is exemplified by the dispositions made for the Gotthard and St. Maurice fortifications. The organization provided for the maintenance of this position is nothing more or less than a regular garrison, of which one may assert, without going into details or maligning them, that at best it is only a makeshift, and that not of the best.

Arguing on these various premises, the writer in the extract that follows compares the peripheral and the cordon system with the radical or the "fortress system on strategic lines":

"The radial system is founded on the assumption that the great war now being waged does not in any way concern Switzerland, save as respects the lines of operation which traverse the country. We set ourselves in opposition to any temptation which our highways, if exposed and unprotected, might offer to a power at war to encroach upon our territory by blocking the approaches to such points as are of vital importance by fortified works.

"The roads available for marching, as far as Austria, Germany and France are concerned, run as a rule more or less parallel to the periphery of the 'plateau,' which extends for a distance of from 300 to 330 kilometers, with a breadth of from 50 to 70 kilometers, from Lake Constance to the Lake of Geneva."

Several of the main entrances to the lines of operation are naturally in the direction of the periphery of the main; as, for example, the Bern-Münstertal-Delémont-Frieburg-Morteau road, or the line of Lake Geneva-Bern, Lucerne, or the Val de Traverse-Solothurn-Brugg-Zürich road.

"While the roads pierce the frontier in a radial direction, they curve more or less in following the valleys of the Jura, the basins of the lakes, or along the courses of the principal streams of the country.

"If we desire to obstruct by fortifications the advance of a foreign army, moving in the direction of the long axis of the plateau, then we must not dispose these along the line of this axis, nor about the circumference, nor on longitudinal stretches, but across and embracing the narrower breadths, with this end in view, that these cross sections might serve to embarrass the concerted movements of the invading forces, so that the columns marching on the longer lines would be brought to a stand before these barriers

before it was possible for them to come in touch with their opponents.

"If the fortifications were erected along the circumference, then only a portion of the central region would, because of the tangled and tortuous character of the terrain, form incomplete barriers on the lines of the radial system, as at Thun, Bern, Bielersee. If the fortresses of the inner portion are not coordinated with those of the frontier, so that they may serve as a support to the outer ring; or if there be only the eternal girdle of forts, then all that the enemy would have to do would be to break through at some one point, and the whole interior of the country would lie at their mercy."

The laying-out of the radial system should in every case satisfy the following conditions, if its establishment is to be of any worth and justifiable:

(*a*) The line selected must directly cover the major portion of the plateau, presenting a front against every chance of invasion.

(*b*) It must intersect the path of main operations of any operations of any and all foreign forces at every possible point.

(*c*) It must be as contracted as may be, so as to require a minimum of construction, and not need excessive forces for the maintenance of the same.

(*d*) The line, with its principal groups, must at intersecting points offer material obstruction to the enemy.

(*e*) It must have strong supporting points.

(*f*) It should not be so simple in character that a break-through in one portion should render the rest untenable. It must consist of independent groups, which can support one another in any emergency.

(*g*) The line must be—and this is of the first importance—strategically drawn on the boundary line where our interests come in contact with those of the enemy; for whatever would be of advantage to the enemy to hold, that must we ourselves firmly control. The value of the ground must not be rated on political considerations, but must be determined by the experiences of the history of the past and by its geographical setting and conformation.

(*h*) The line must be so designed that one and the selfsame range of works may serve equally well for any contingency that may arise.

(*i*) It must be not merely a bare barrier, but so organized that, if for the time being we are not able to hold our position in the field, it may serve as an efficient shield for the whole army.

(*j*) And, last of all, the system must be financially practicable.

All of these conditions lean then to the conclusion that the lines of the said radial system should at the same time present a front against the west, east, and north, the works being laid out as follows:

1. From Blauen over the pass and to the outlet of the Balstaler Klus;
2. Olten-Aarburg-Hauenstein;
3. Brugg-Baden, with the points bearing on this central stronghold—Staffelegg, near Oerlikon, near Bremgarten.

The whole proposition, especially in the fundamental principles, is certainly permeated with a strong geometrical flavor, something quite different from our modern methods of treatment, but at the time it was written very much in fashion. There is in his essay a continual use of terms, such as geometrical side, points of intersection of radials and opposing lines of operation, secants of value to ourselves or to the enemy, etc., terms which today might be considered repulsive and sound strange to our ears. But if one studies the proposition attentively, taking the trouble to follow up the calculations on the map, he cannot deny but that the reasonings are most logical.

It is certainly worth while, in the defensive system of Switzerland on the first line, to checkmate every impulse of an aggressor to break through the neutral land. For such an end it is essential to have our forces right on the spot to hold this first line. For such a purpose it will not serve to dispose them exclusively along one determinate front, but they must face in all four directions; for only in such wise can this impulse be checked. If the land defences are arranged so as to cover only one front, and if, by the chances of war, the danger of an invasion threatens not at that point but on one of the other three fronts, which have not been made secure by permanent works, then must the fortifying, just as the danger is impending after the outbreak of hostilities, be done provisionally and after a helter-skelter manner; in other words it must be improvised.

But every improvisation has in it something incomplete, something unforeseen, which can only be remedied or adjusted if some happy chance affords us the necessary time.

In the whole problem of our land defence there appeared a new

need with the opening up of the Gotthard tunnel and road. There came at once a demand for some system of fortified defences for this line, above all for tunnels, their greatest and costliest structures. The public in ever-increasing numbers had its attention directed to our southern front, which up to that time had in the entire discussion of defences been practically neglected.

In support of the new ideas there appeared a certain pamphlet entitled "Our Southern Frontier," which was published in Zürich in the year 1886. It made a most earnest plea for the fortification of our southern border, and made definite proposals as to the character of the same. There was to be built a central stronghold at Bellinoza, measures taken for the security of the Simplon road, a covering for Furka and Crimsel by means of works erected at Ulrichen, in Oberwallis, protection for the Gotthard tunnel by establishing forts at Airolo, the fortifying of Samadan so as to secure the Bernhardin and Splügen, as well as the Maloja and Bernina Pass.

A stimulating cause of all this was a certain feeling of animosity against Italy, proceeding from a series of personalities in military complications, which dated from the time of foreign service or other associations.

When the proposals for permanent constructions for the security of our country came up before our National Council for final decision and materialization, the Commission entrusted therewith decided on the erection of works in the Gotthard region and at St. Maurice and modernizing those of Luciensteig belonging to an earlier period. In all these the dominant idea was the same as has been evolved from the radial system. It was hoped that by the combination of these with the permanent fortifications of the first line, any disposition on the part of a foreign power to violate our neutrality would be discouraged. The calculation was that, as the Gotthard works would command the northern front, they would serve to protect the most important avenues leading from north to south, and at the same time furnish a substantial support in the rear of the forces operating on the plateau; Gotthard, St. Maurice and Luciensteig as a group, reciprocally supporting one another, would control the southern approaches of the Alps, while from east to west there would be a mutual binding together of the defences. That the idea as a whole, as originally contemplated, has not been fully realized has already been noted in several places; we will therefore not dwell upon it now.

In our land defence system we have to go through the same experiences as have been met with elsewhere. It will never be sufficient, by the fortification of only a few points, to secure one section and leave another exposed; for not only are military opinions and methods fluctuating, but political constellations are ever exceedingly unstable. Therefore, whatever the system may be, one may never declare that it is absolutely fixed and determined, but it will, as may be seen in the rapidity with which artillery and its equipments become obsolete, create a constant demand for modifications within, as well as annexations without. We may, however, consider that the fortified defences of the plateau are an accomplished fact by reason of the permanent structures upon its commanding eminences.

VII.

With the inception of the use of gun-equipped and armored towers, transportable and easily assembled or taken apart, there was placed at the disposal of the art of fortification a practically new agent, whose importance has already been dwelt upon. The same has been true of constructions from iron sections, which can readily be used in the making of provisional defences. Both of these together made it possible to a certain degree to lay up in storage in time of peace a supply of matériel which, when occasion demanded, could easily be carried and put together at any point desired. This has been especially considered in the prospects for our land defences, as in the establishment of the central fortifications at Zürich, Berne or Lucerne. The projects for the conversion of Lucerne into a kind of Helvetic Plevna have laid especial stress upon the equipment with movable armored guns of the Schumann pattern and the accumulation and storage of elements of armored defences. This matériel should be kept at Lucerne, if it were deemed desirable to build at that point, so as to be most conveniently at hand. It could easily be transported elsewhere, if necessity demanded the setting up of the wandering fortress at any other point. The advantage was theoretically discussed and acknowledged, that after the erection of such defences they could be taken apart and be reassembled at any other place. In practice this has already been demonstrated in the present war, at least so far as the mobility of heavy armored guns is concerned. It is well known that the artillery defences at Bucharest were greatly strengthened through the provision by which there was an equip-

ment of towers of the Schumann system. These, alongside of the long and shorter range pieces, and occupying positions between batteries, rendered most effective service. But as in the progress of the Rumanian campaign the investment and pressure upon Bucharest became more and more severe, and the maintenance of the fortress, calling for a strong garrison, became increasingly more impracticable, the Rumanian command, while there was yet time, determined to abandon the capital as a citadel and to transfer the defensive matériel and guns to another point. This was accordingly, at least in part, effectively accomplished, so that not only the artillery and its belongings, but also the transportable defensive devices were safely transferred to the line of the Sereth, and there reestablished. Any change in location and utilization practicable for the end desired of such movable ordnance and armor is only to be thought of under the condition that a corresponding well-organized network of railway lines is at the disposal of the operating forces.

There belongs, therefore, to the preliminary preparations for land defence not only a precise and well-considered determination as to the points and lines which, always according to the military situation, require to be fortified, a careful elaboration of the plans of fortification over the whole region, every detail being thought of, so that when the call comes for their employment there can be no doubt as to the nature and manner of their provision; but there must also be such a coordination of the railway systems that every time it becomes necessary to move from the central magazine to the point that is to be defended its supply of ordnance and fortifying matériel, there will be no hitch nor miscalculation in the way of a prompt delivery.

For such mobilization there must then be provided the necessary tracks leading to the magazines, there must be ability on the part of the railroad service to furnish the transportation required on shortest order, and the matériel must be hauled and delivered at the points required to be fortified in such fashion that the parts may be most readily assembled. By the employment of improvised material in conjunction with the portable armored towers in the way laid down certainly the best results may be looked for.

And it must not be forgotten that the entire equipment should from time to time be subjected to a thorough inspection and going-over in order to be assured of its fitness for the purposes intended, to see that parts have not become obsolete, to set up the guns and

fortress matériel in order to correct and adjust whatsoever might be out of the true, or what may not come up to the standard. The inspection has particularly to do with ascertaining whether the covering material and armor plates will still furnish sufficient resistance against the ever-increasing power of artillery impact, and whether the capacity of the guns comes up to the requirements as to range penetrativeness, explosive and spreading action.

The nature and manner of employment, as well as the functions of armored guns of large caliber, were, at the time when these weapons first came under the eye of the public, well set forth in a book bearing the title "Metz defended by armored fronts," whose author was a Switzer—at that time a captain—Julius Meier. There was given a graphic presentation of the organization of such an armored front, the disposition in the intervals of artillery and infantry, as well as the conduct of an artillery engagement against a hostile offensive. Here we already find a massive and continuous discharge that may be compared to the drum-fire, the barrage of today; that is, of a rapid, unintermitting succession of a vast number of shots, giving thereto a great formidableness, and in whose destructiveness and especially its demoralizing effects is found exactly that upon which the principles of the methods of present-day warfare are grounded.

The direction as to firing is given from central points, which communicate by means of telephonic and telegraphic connections with a certain number of armored stations and towers. All of the arrangements for the battle are based upon an accurate preliminary survey of the field, determining the connection with the central points by observation stations selected and established with this end in view. The aim and time of firing were determined by a system of firing-tables, and controlled from the fire-directing point, so that a single armored gun was the only controlling voice.

The handling of the portable sections for fortifying, as well as their employment, has been especially treated and threshed out by the German engineer officer von Giese in a book widely read in his time—"The Methods of Fortification of the Present and of the Near Future." For the construction of horizontal covers capable of offering adequate resistance there should be kept on hand a supply of rails and steel ties also of corrugated iron, the same to have their necessary covering of earth. The writer would accordingly do away with the weaker timber and brush matériel, and by means of previously prepared parts shorten appreciably the time of

throwing up of such fortifications. The use of concrete would also play a considerable part in the work; and here again the corrugated plates would serve as a reinforcement both for facing and strengthening.

According to the idea of the Russian Engman, the concrete plates are available for use by the sapper in his advance work, serving as a cover and stayed up by supports. It has also its importance as shortening the time of the operation, as the tunneling will not be held up nor interrupted, the concrete plates serving as an effective shelter from the very inception of the work. As an aid in the methods of protection under consideration there have been designed for the setting-up of gun-shields portable armor for 5.7-cm. rapid-fire guns and an armored carriage for 12-cm. rapid-fire howitzers, capable of dismantlement and reassembly. For the defence of Bucharest there were approximately 60 armored towers for 15-cm. and 12-cm. guns, over 70 armored carriages for 21-cm. howitzers, and a great number of armored carriages for disappearing rapid-fire guns. Finally some 300 long and short range field pieces were held as a reserve supply. One can see from this for how many guns they must reckon, and can therefore get some idea of the expense involved by this method of defence, even if every effort be made to exercise the closest economy.

Concerning the whole ordnance project the writer thus expresses himself: "The portable shield can be effective only against an actual assault. Against artillery fire it is practically worthless, its proper place being with howitzers. The employment, then, of the armored cover as of something presumed to be absolutely indispensable is a proposition untenable. One must then renounce the idea of putting those field pieces in command posts and restore them to infantry posts suitably strengthened by armor.

While there has been in the movement in favor of transportable gun-towers and fortress matériel much developed that is good, and some that is quite corrupt, and the discussions have been quite lively in character, to which the instance of Plevna contributed not a little, still a determinate course as to a system of land defence has not been finally adopted by us even though armored towers and guns protected by armor-plate have been employed in the fortifications at Gotthard, as well as at St. Maurice, and there in still greater measure. And yet here we have to do with armored guns which, in the total make-up of the works, have been permanently

established, and are therefore no longer elements that may be transferred from one point to another, but constitute integral portions of the structure.

How varied, all things considered, are the views concerning these theories, especially among authorities of greater weight, has been sufficiently illustrated by the citations already given from the writings of Schlichting, von der Golz, and Bernhardi. While Schlichting has been qualifiedly conservative in his judgment as to the fortress-errant, the position taken by the others in this regard has been sufficiently favorable, and especially have the Schumann armored towers found in von der Golz and Bernhardi warm advocates.

Among engineer officers also there has been considerable difference of opinion; on one side a hearty approval, on the other side again as pronounced disapproval. As an example may be cited a passage, which treats the whole subject in a spirit of irony. It proceeds from the pen of a well known German engineer officer, Reinhold Wagner, whose excellent treatises on fortifications were at one time widely read and consulted. He says: "The general opinion is that there is not much reliance to be placed on armored guns, even of the stoutest construction, as adjuncts in the strengthening of permanent fortifications; but the lightest armor of the Schumann pattern seems to be regarded not only as an infallible strengthener for improvised defences, but there has appeared, like a *Fata Morgana,* a more advanced type of the same sort—the mobile fort. The only use they can have for such forts is to pack them securely away in sections in some peace depot, held there for shipment by rail, ready to transport when the time calls here, there, or anywhere, whatever the orders may be, and then to be set up with all despatch."

VIII.

In the preceding section of this article it was noted that there must be a constant supervision and inspection—of the covering matériel to verify its capacity for resistance, of the ordnance to test its range and penetrative power, in order that the outfit of the fortress be not suffered to become obsolete. This leads naturally to the never-ending conflict, which in the art of fortification has been, and is being, fought out between the means for protection and the effectiveness of the artillery, or in brief—between armor

and gun; and which has already had for a considerable period a dominating influence in every branch of naval construction. On the whole, as far as expenditures are concerned, it has gone better with naval work than with that on fortresses: for fortresses, unfortunately, become antiquated and out of date as rapidly as war vessels. An appropriation of fifty million marks is made for the building of a great battle ship with the sardonic realization that in the course of twenty years it will become a mass of junk. Such a future faces us, not only on the sea, but also just as much upon the land. So we must logically concede to permanent fortifications their periods of life as much as we grant the same to ships. And yet, if a chief military constructor proposes to put some antiquated fort in proper shape according to the canons of modern art, then the senators' very hair bristles, although the motion may have to do with a much more moderate expenditure. Such conditions are to be met with in all states, our own country not excepted, and always more or less alike in tone. They go ahead, here and there strengthening a part, sometimes even building an entire group; but at the best the tendency is to be satisfied with patchwork.

Above all, the controversy between artillery and covering, between armor and gun, is as old as war. It dates from that point of time when there were first employed ballistic machines for hurling rocks and beams against the enemy's walls and barricades. The conflict became more acute as in Europe guns came into use, and by the explosive force of powder huge stone balls were effective in destroying the walls of cities and castles. It reached its culmination when concrete began to replace masonry, and guns to be shielded by armor-plate. The first and handiest means employed to parry or resist the enhancing power of mechanical devices for casting or hurling was to make their walls stronger, and in order to shield themselves against stones falling on a steep trajectory was to avail themselves of vaulted shelters. Since the impact of these missiles, before the use of powder as a means of projection, was not particularly strong, such devices served their purpose very well for the time being.

Conditions began to be very different as the use of black powder became more general, as there was going on a constant improvement in the manufacture of ordnance, and as alongside of the straight or direct fire there developed a curved trajectory, the missiles falling from above. At this point a simple wall and arched

shelter no longer served their purpose, and other means had to be devised adequate to the new demands. It was found necessary to lay before the walls or over the arches a stratum of earth, and where that was not feasible, to avoid as far as was practicable the action of a direct fire on the masonry. The artillery of the defence, which for a long period had stood in the open on the walls, was now sedulously protected more and more against the direct and indirect fire of the enemy. Casemate batteries were established, and the more the power and range increased, and the explosive effects became more destructive, there followed naturally the invention and employment of armored towers crowned with metal domes, and with a strong jacket of reinforced concrete. The endeavor was also made to diminish as far as possible the visible target, so that there would be a minimum exposure of mark to the enemy aiming at tower or dome, and besides this, by an ingenious construction of the carriage, in some instances at least, the gun was only exposed at the actual moment of discharge.

In a pamphlet, which has to do with historical experiences in war and during peace maneuvers, and which touches also upon fortress warfare, under the heading of "Battle between gun and cover," is found an epitome of observations on a much discussed subject: The question whether artillery alone is in a position to make possible an attack on the works by infantry, or whether more than hitherto the engineer must be called in as an auxiliary; whether it is only possible for him by mining to clear the way for the free delivery of an assault.

The whole question may be regarded from many points of view. When it comes to the actual test the matter must be decided from the very beginning by the military timbre of the command and the commander. From a theoretical standpoint there must be assumed —for the offensive unfavorable, for the defensive favorable, conditions. The less they can count in a fortress on an abundant supply of matériel and of personnel, the more must the issue depend on psychical conditions. Field and fortress warfare have their immutable laws which, independently of all changes and development in their technique, are grounded upon the very nature of war, which depends not merely upon the character of inanimate weapons as employed, but beyond and above all are determined by the spirit and morale of the forces engaged. The history of siege warfare shows what an incredible degree of mental and

physical ordeal the human soul is able to pass through without breaking down. We should appraise then at their full value personnel and matériel alike.

In France, General Langois, in Germany, the military historical section of General Staff regulations for siege artillery, have gone into this question thoroughly. Under a tempest of fire, sweeping over the entire field, any manipulation of the fort's artillery will be rendered impracticable, while the defenders will be driven from their stations, so that the approach of infantry and the clearing away of obstacles become possible. There is no disputing the certainty of such an outcome. But now that the infantry, by the assistance of the siege artillery, have reached the ditch zone, where the support of their own heavy guns must be dispensed with, lest they should imperil the safety of their own troops, then there devolves upon the line a new battle programme right on the edge of the counterscarp. As soon as they are within this ring their own artillery is mute. And here is where the engineer, or rather the sapper, must come in; for so long as the obstacles of the moat are not overcome an assault by charge is unthinkable. If then the cooperation of the various arms of service, in siege work as much as in field engagements, means anything at all, it is no less true of the engineer, who must be held in reserve and all prepared for action at the right moment; while at the actual launching of the assault every technical operation must devolve on, and can be accomplished by, the thoroughly drilled infantryman.

The great losses in their scanty contingent of engineers in the Russo-Japanese War were the cause of the delay on the part of the Japanese in taking Port Arthur. It made it all the worse that only picked line troops manned the defences of the fortress, while the Japanese artillery, in caliber, explosive effects, and fire tactics, was not up to the mark; at all events, it was not able to demolish the Russian bombproofs. In the present war, as has already been proved, and later on will doubtless be more fully demonstrated, there can be no doubt of the victory of the gun over the cover. It has been attained by employing artillery of greater caliber, and by loading the shell with explosives of as yet unsurpassed power. These have especially made it that they can dispense with firing directly at tower or dome, because now the striking of the concrete shell effectually crushes and rends the concrete, wrecking the tower to such an extent that, as far as gun and cover are concerned, their

value in the conflict as a battle asset may be practically eliminated.

IX.

In a study which appeared in 1915 in the *Technical Military Journal for Officers of All Arms,* entitled "Importance of Permanent Fortifications and Their Modernity," the definition of the latter term is this, that a fortress could only deserve the title "modern" if it answered to the following conditions:

If its works, in design and grouping, conform with present-day tactical principles;

If its artillery and engineer equipments and outfits possess unquestionable superiority over the artillery and engineering appliances of the enemy;

If its structures have a superior capacity for passive resistance against the offensive's material for attack;

If its immunity against assault is of such a character that, with the means at his command, it would be impossible for the adversary to overcome it.

Under the condition of these hypotheses must then the following judgment be passed upon the fortress of more modern date. The test is bound to be severe, as the reality will show.

With regard to the consternation which the 42-cm. caliber gun caused, it is a matter of fact that neither armor nor the masonry of fortresses that had stood for many years were able to resist the action of siege-guns of models prior to these, and accordingly such could not be classified as "modern." In a tactical sense their arrangements did not rise above a scheme that had become obsolete, and which had many defects, as might be seen in the massive French fortresses, whose experience has certainly been disastrous. They had also failed technically to attain as high a standard as they might, neither in what armor, or what concrete was capable of being. They were "modern" according to the so-called New-Prussian system of fortification of the forties and early fifties of the nineteenth century; for all their aggressive and defensive appliances were then superior in power to anything the enemy were able to bring against them. It may truly be said that they gave, because of their ponderous strength, a new impetus causing a revolution in the province of artillery. But from the moment that this had been accomplished, and the fighting capacity of artillery had acquired a considerable access of power, then these fortresses soon began to be unmodern. The fortifications on grand scale of

Antwerp, belonging to the sixties, which the genius and scientific skill of Brialmont had devised, were at that period essentially modern; but as tractable mortars appeared upon the scene, and the action of the great guns became more formidable, the once wonderful defences of Old Antwerp soon became relegated to the unmodern class.

"The art of fortification must be always on the lookout for new devices, in order to hold its own in the race with the ever-developing art of attack; and so the armored shelter has little by little forced its way into consideration as a mighty factor. But a new leaf has already been turned over. The time has long since passed since the stoutness of defences has been the stimulating cause for the invention of new or improved weapons for their demolition. It is rather the latter which now dictate the degree of strength that fortifications require. And so in the race the question rather of the expense of construction has become increasingly obtrusive. As the sums demanded assume such vast proportions, then the legislators throughout Europe shake their gray heads, and military constructors in every country are obliged to be satisfied with compromises! In the political arena, and in the world of finance, this may be done with impunity, but in war administration—never! In war it is only the best and most reliable that will answer. Every compromise must be refused; for every compromise is only the veil or cloak of the inadequate."

The article makes a sharp tilt at the opinions of those who, instancing the precedent of Plevna, advocate the substitution of trenches in place of permanent fortifications, who say: "See the trenches in the field. They cost nothing, and yet render better service to their constructors than do the forts." Shelter trenches, under certain conditions, might well be valuable accessories to the fortress. They can never be its substitute.

"If it should be the prevailing sentiment to abandon those ancient fortresses scattered through the land, valueless for any military purpose, and only suffered to remain and be maintained because they have thus stood for the last hundred years, although they have no longer any strategic significance, such determination would be all right. Only as they might be employed as constituent elements in the sum total of land defences could any worth be attached to them, and then only as they have been kept up to the standards and requirements of modern times. Since political high-

lights and military authorities are at variance, we may not venture to hope that defensive systems will be shaped after any coherent programme but must fain be content with what may be accomplished when the actual contingencies arise.''

For the purposes of land defence this study places little value on isolated fortresses scattered here and there contiguous to the border, serving perchance one and another purpose. As a practicable support for the vital defensive force, the mobile army in the field, and for the effective protection of the country against hostile invasions of greater or lesser magnitude, he would rely principally upon the utilization for operations of long open stretches of frontier, commanded by systems of fortifications, and flanked by extensive reaches which will offer passive, impassable and insurmountable obstacles, whether natural or artificially constructed, these lying as close as possible to the border, shielding the back country from the devastation incident to war.

Under such a system of defence there is no idea of organizing great enclosed and entrenched camps of the old style, such as the French maintain from Belfort to Verdun, linked together by a chain of auxiliary forts. A satisfactory solution of the problem is better arrived at by laying out permanently well planned and prepared battlefields, where one's own offensive may have free range and everything favoring an advance, while the enemy's offensive would stand the chance of being shattered under every circumstance. Of course it is to be understood that such pre-arranged fields must not be in the air or isolated. There must appertain to them substantial supports for the wings. If there exist outstretching natural obstacles, so much the better; if there are none, then they must in some way be contrived, either by a skillful utilization of water courses or by afforestation, long stretches of planted timber flanking the positions selected for operations, many kilometers in depth, and with an impenetrable jungle of undergrowth. The best conditions are those where forest, water and swamp combine, especially so, as modern science is devising methods for preventing or retarding the freezing of the water elements. At all events the object is to interject between these fields of operation reaches that will be practically impassable for troops, blocking every movement of armed forces throughout their extent. By this arrangement the broad unobstructed expanse on the border will afford and provide most favorable conditions for operating, and

will at the same time be able to control the movements of the enemy, while in their own domain, behind the best of shelters, they are protected against the devastation to which the frontier is ordinarily subject. The great advantages of such a system are self-evident, as the tactical conditions are such that the operations are restricted to the border.

Among us, as has already been noted, a proposition was made by our present chief of engineers, which to a certain extent recalls the system just mentioned that is—of permanent pre-arranged defence zones. The idea was to employ our engineer forces here and there over the whole ground, in order gradually to complete our land defences.

Situated as our frontiers are, and with the conditions that confront us, there is hardly room for doubt on which zone there is the most urgent call for defence, and where the work necessary should be done with all thoroughness. At all events, upon the outbreak of war, plans and specifications for the framework or skeleton of such a system as has been realized at Jolimont, as well as at Hauenstein, would have been heartily accepted. It is to be regretted that the extension and improvement of such precautionary measures have not received the attention they deserve. The disposition has been rather to depend on combined strategical maneuvers on a grand scale, to which the contour of our country imperfectly contributes; even as far as these are concerned there has been too much neglect in drill and exercises in what would be to us to-day of the utmost value.

According to the dictum of a distinguished authority in the art of fortification, the field fortification is "tactics inscribed in stone." In these few words is crystallized so great a truth that one may set it down as an axiom infallibly applicable to the art named. Otherwise expressed it would read: "Permanent fortifications pertaining to a previously arranged battlefield must conform with requirements of tactics just as much as the field-works." This means nothing more nor less than that every cut-and-dried formula, every reminisence of how things used to be done must be set aside and ignored. "The engineer officer must know what problems have to be solved in the zone concerned, and then he decides, in accordance with the tactical ends in view and the nature of the terrain, what will be the location and form of his arrangements. In a technical sense he is bound to conform to

certain fundamental principles. Every form which is in accordance with these principles is right, provided that it fits in any wise with the character of the ground. The engineer officer must thoroughly understand that he must emancipate himself entirely from the thraldom of the antiquated and traditional, and that he must feel perfectly free in the methods he pursues for the solution of the problems that confront him. Tradition is certainly a fine thing for one's guidance, but one must beware lest it become a chain. Tradition is in a higher sense a treasure, a legacy of untold value, but if it becomes a formula, a rut, it degenerates to a dull pedantry. Under present-day conditions, when we have to figure on such formidable instrumentalities for attack, such as artillery, the engineer department, and aerostation provide, the old forms are of no worth—away with pedantry!'

From conclusions such as these we are brought face to face with the following considerations, which are worthy of all regard:

"How effectually such pre-arranged offensive and defensive battlefields may be laid out on the sphere of operations, with efficient supports for the wings, may only be determined by the conditions as they arise. There may enter into calculation either groups or lines of defences. Each class has its claim for consideration, but only so far as they fit in with the tactical problems and the character of the terrain. Therefore it is not well to be tied down slavishly to one or the other. At all events, in order to assure a stout holding of the field of operations and to husband the strength of the defensive for crises, strong, well-contrived, storm-proof, well-enclosed works commanding extensive areas can not well be done without. They serve to constitute the framework or skeleton of a complete system, which may not be penetrated or broken through without the previous capture of a number of outlying works of similar character. They are the powerful supporting points for the close contest, on which intermediate positions, some in part prepared beforehand, some thrown up by the troops themselves at the time, rest as on strong pillars. They constitute, with the infantry as intrenched, a cover for the field batteries, whether these have been beforehand armored in time of peace, or are naked guns with such protection as the troops on the ground may be able to improvise."

As essential factors for the stoutest maintenance of a dangerously threatened position will a line of works, arranged after

the fashion of a chess-board, serve an excellent purpose under certain conditions; as thereby is afforded a mutual support, and the most effective resistance is assured. Redoubts also should enter into the calculation, which must be wholly intact when an enemy who has penetrated the first line must run against them.

In the laying out of these supporting points and works there can be predicated no conventional rules of measurement. These can only be determined by conditions as they exist and by experimental tests. If such measurements be predetermined it may happen as with the military constructor of "Platz in Graudenz" and the old engineer officer inspecting a work which fails to satisfy him: "By computation this wall should be six feet thick; for my own better security I would add a foot; but for the safety of His Majesty two more feet." The wall stood.

The general principles in the formation of such modern supports and enclosed works are fixed and definite. They call for:

1. An annihilating fire capacity against the enemy from close quarters to his final stand.
2. A fire support of adjoining works, sweeping of intervening ground, flank delivery.[1]
3. Absolute immunity from assault.
4. Blocking of a hostile lodgment within the lines.

To satisfy the first of these requirements present-day conditions demand two means: to protect the guns with the heaviest armor shields, and to conceal and render invisible the entire battle outfit.

"By the fire from the works, which still have a firing-line in the open parapets, the garrison are directed in the heat of the bombardment to hold themselves ready in the dugouts, which afford a secure shelter. But as soon as the fire of the enemy's artillery slackens they must avail themselves of the moment to man the parapets on the firing-line, in order to resist the anticipated assault. The men gradually and cautiously wend their way through the traverses leading from the dugouts, the outlets being hermetically sealed against the pneumatic effects of the fire of the heavy howitzers and explosion of shells.

"Where, in consequence of shell explosions, the trenches have been torn up, the front and reverse parapets destroyed, the breastworks a chaos, any speedy occupation of the firing-line in question,

the functions of the leader, not to speak of the direction of fire control, become quite impossible. If the trench contingent is decoyed back to its station by a feigned attack, and is then met by a heavy rain of projectiles cast by mine-throwers, etc., then must the decimated ranks return again through the maze of runways to shelter, there anew to await a fresh alarm that will re-summon them to the trenches. If now, by some particularly well-directed shot, the refuge, with the men therein assembled, is demolished, it means the irretrievable loss of a material portion of the defenders. A body of men so badly shattered as this will naturally break down in facing a charge. In such extremity either a fire support from the adjoining works, or one from their rear, becomes impossible when friend and enemy alike would be exposed to its fury. If the artillery of the attack gains a fire superiority, then the infantry has to come up to the front with their machine-guns. The decision lies in their hands. They must not be possessed of fear of anticipated losses, but must depend on their nerve and grit to meet the oncoming attack of their adversaries. This is where the work of the military constructor counts, where he will have had the works in such perfect condition that the entire unbroken and unimpaired strength of the defence may take their posts, and be all ready at the crucial moment. And this duty will only be satisfactorily accomplished, if the means necessary for the purpose shall have been provided. If they have been refused, then in the last extremity it will be no wonder if the troops refuse."

In order that these demands be properly met, there is only one way, and the call is sharp and peremptory: "All under armored shields, no stationing any longer along the exposed wall." But if this is to be done, money is needed, and this money will have to be appropriated, if we are to have defences fit in every respect to furnish the resisting power required.

What the details in form of armored defences should be is a problem that naturally suggests diverse solutions. One idea is to have within an enclosed space an armor-sheathed gallery for infantry and machine-guns, running its entire length.

An arrangement of this kind would probably be, as far as fire-control is concerned, the most advantageous method; and indeed it calls proportionally for the least development of a work; but it would have to meet the tests of today, which above all requires

the circumscribing—the minimizing—of erections of any kind that are liable to be damaged or destroyed. Even a series of strong bulkheads would serve only imperfectly to obviate the difficulty. It would also not be easy to conceal such a long-extended gallery from the observation of the enemy.

On all accounts it would be more advantageous to have as many as possible of small armored stations for machine-guns amidst the shrubbery, so disposed that they could not easily be descried and recognized by the enemy. Whether such armored stations should be for one or two machine-guns, whether the armor should be permanently fixed, transportable, or portable, could only be decided according to judgment after going over the ground, before any safe conclusion could be reached.

As here the question of expense must naturally play an important part, the cost, and its solution should be, not what is cheapest, but what is best; for only the best is good enough to assure the most satisfactory results. The pieces employed for barrage also should be sheltered in armored towers, externally unrecognizable as such, and scattered irregularly through the works, or over the field. "If these dispositions are skillfully effected, they will not have the appearance, from without and from overhead, of fortified works. Rather must the adversary get the impression of an undulating stretch of landscape, with here and there a clump of timber or a bit of shrubbery visible."

All things considered, there is ground for a reasonable conviction that in the conflict between gun and shelter, while the odds have hitherto been in favor of the gun, that the tide may turn. "The man who has designed the weapon knows also how to forge the shield."

(To be concluded in the next number.)

WHARF EQUIPMENT[1]

By

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The transit shed is the first and most important item of wharf equipment. At New York and elsewhere the shed is limited in dimensions by the size of the pier. There is little choice in the size and proportions of the pier transit shed. The result has been that the pier and the pier shed have been considered as one and the same institution. This is not the case in theory, and in other ports with greater freedom of action is not the case even in practice. The transit shed is a thing apart.

The function of the transit shed must be kept clearly in mind. The transit shed is a covered structure to give protection from weather and pilfering to a cargo in transit between ship and land. When a ship makes port, it must discharge its cargo as rapidly as possible and can not wait with this unloading to allow the cargo to be taken away. The cargo must also be spread out to afford opportunity to sort it according to marks and consignees. During this time, from the discharge from the ship until the goods are sorted and moved away, they must be protected. Likewise in loading, when a ship arrives and has its cargo all out it must load the outgoing cargo as rapidly as possible. This is only possible if the cargo has been assembled beforehand and sorted according to ports of destination and nature of the goods. The stevedores can work rapidly and load correctly only when the cargo can be loaded and stowed in the proper sequence. Stowing according to port of destination is very important when the ship is to call at several ports, as for instance on a voyage to South America.

Size of the Transit Shed.—It follows from the foregoing that a transit shed must be sufficiently large in area to hold the cargo of the largest ship using the landing, and in addition to hold it

[1] Reprinted by permission, from "Ports and Terminal Facilities," McGraw-Hill Book Company, Inc., 239 West 39th St., New York.

spread out for sorting with aisles between the piles of cargo at frequent intervals. The cargo must have space enough without the need of piling it more than shoulder high, as this piling or tiering is very expensive and time consuming. Goods may be tiered in a warehouse, but should not need to be tiered for the two or three days that they are in the transit shed. The transit shed must have an unbroken floor space sufficient in area to perform this service of smooth stevedoring without congestion.

What is a sufficient area? One way to get at the answer is to consider the latest practice at some of the best ports abroad, where there has been sufficient room to build sheds the size wanted without being limited by the size of the pier. As first example may be noted one of the latest quays[1] in Hamburg with three sheds of a combined length of 965 meters and width of 42 meters, or 40,523 square meters. This would mean a length of sheds of about 3,210 feet (1,070 feet to each shed) and a width of 140 feet, or nearly 450,000 square feet of space. The quay wall is 1,090 meters or 3,610 feet long, 400 feet longer than the combined length of the sheds. This would give an area of 150,000 square feet for each shed. Assuming an average required capacity for 15,000 tons of cargo to each shed the allowance made is 10 square feet per cargo ton. The area may have been calculated at one square meter (1.196 square yards) per cargo ton for a somewhat smaller average cargo. Such a quay would accommodate six 12,000-ton gross (B. R. T.) steamers as to length, but when the quay is full there would be an accommodation of only half a shed for each steamer. A cargo ton measurement is 40 cubic feet (2.83 cubic meters). Ten square feet would accommodate one cargo ton piled four feet high. At this calculation it would be necessary to tier above four feet to make the aisles, otherwise the 15,000-ton measurement of cargo would completely cover the shed floor at an average height of four feet. At Bremen the tendency has been to shorten the sheds and increase the depth. The first sheds to be built in the "free zone" were 40 meters deep while the later sheds are 66 meters deep. The latest Bremen sheds are 216 by 640 feet, which gives an area of about 140,000 square feet. This is a smaller capacity than that of the Hamburg sheds, yet, still assuming 10 square feet per ton of cargo, the shed would accommodate 14,000 tons. As this is about the limit of cargo capacity of ships coming to

[1] Augusta Victoria Quay, opened 1903.

the port of Bremen (the very large steamers all dock at Bremerhaven) the accommodation for cargo calculated on the above basis is sufficient.

An important feature of the increase in the size of the sheds is that the only way to keep pace with the size of the ships is to increase the depth of the sheds. Granted that sheds should be as long, or nearly as long, as the longest ship using the berth, a simple increase in the length of the shed will not afford sufficient space on the shed floor to accommodate the increase in the size of the cargo. When a ship's size is increased it is in linear measure, but the cargo capacity at the same time is increasing in cubic measure while the shed floor is only increasing in square measure. A ship 500 feet long is 25 per cent. longer than a ship 400 feet long, but the increase in cargo capacity will be considerably more than 25 per cent. To accommodate the increase in the capacity of ships it is necessary to increase the length of sheds, but the depth must be increased even more. This fact accounts for the pier congestion at New York where it has been possible to increase only the length and not the depth, *i. e.,* width, of the pier and its shed.

Recent New York practice, as found at the Chelsea piers, is to make the shed a little less than 120 feet wide and about 900 feet long (the pier deck is 1,000 feet in length), or an area of about 100,000 square feet. This would afford a capacity of 10,000 tons of cargo. However, the Chelsea piers are of two stories and the Hamburg sheds of one. At Hamburg it is the custom to move the ship from the discharging to the outgoing shed. Granted that both decks of the Chelsea pier shed are used for freight, the upper for outgoing and the lower for incoming freight, which is not always the case, the shed space is about two-thirds that of the Hamburg shed. It is confusing for a moment that the two-story shed does not make a total area of 200,000 square feet at the Chelsea piers as against 150,000 square feet at the Hamburg, or 140,000 square feet at the Bremen shed. The joker is found in the practice at the two Hanseatic ports of using different sheds for incoming and outgoing freight to avoid any possibility of confusion. Rather than warp the steamer across the slip or basin, the American practice has been to build double-decked sheds with the upper deck for incoming freight and the lower floor for outgoing freight. Such a pier shed is a more intensive use of the waterfront, but the cargo can not be moved so easily. On the other hand, it is easier to move a ship

in the European basins because of less current and easier angles.

One of the best American authorities on ports, Mr. McL. Harding, President of the Society of Terminal Engineers, has worked out another theory of pier transit-shed size. As this was received later than the writing of the above and as it represents an absolutely independent calculation it is given here in full.

Harding's Calculation of Shed Capacity.—It is a good rule to plan the shed for such a capacity that it will be possible to distribute all the goods taken from one ship berthed opposite to it. This is the rule at Hamburg, Germany.

When goods are handled by hand the average height of tiering or piling is about five feet. It is, therefore, evident that there would be

(Photo by author.)

Fig. 38.—Quay at Stavanger, Norway. Loading from rail to ship's side.

required a very large floor area to distribute and place a cargo of 6,000 tons according to the marks and crossmarks, especially in a miscellaneous cargo.

Assuming 60 cubic feet, instead of the marine 40 cubic feet, to represent the volume of one ton and 16 per cent. more for distributing space, this would equal about 70 cubic feet per ton. Six thousand tons would, therefore, represent a cubical content of 420,000 cubic feet, and, at an average height of five feet, would cover a space of 84,000 square feet.

The reason for the five-foot height for average tiering is that manual lifting above this height means a considerable increase in the handling expense. It is more economical to hand-truck 400 feet than to lift 10 feet by man power. By mechanical tiering, freight can be tiered 20 or even 30 feet with little if any, additional expense over tiering five feet.

Assuming an average height of tiering at 15 feet, a building could be made 56 feet in width, 500 feet in length, and yet have a capacity on

the above basis of 6,000 tons, at 70 cubic feet per ton. In order to allow even more floor space for the distributing or a greater holding-shed capacity, 20 feet may be taken as an average tiering height. A shed, therefore, 60 feet wide, 500 feet long and with a clear height below the girders of 30 feet, tiering 20 feet, would accommodate 8,500 tons, allowing 70 cubic feet per ton. This, or a shed 400 feet in length, would be a properly proportioned shed for inland river terminals.

It is interesting to note that 60 feet is the standard width of inbound railway freight stations.

If the width of the sheds can be kept within the above limits, the cost

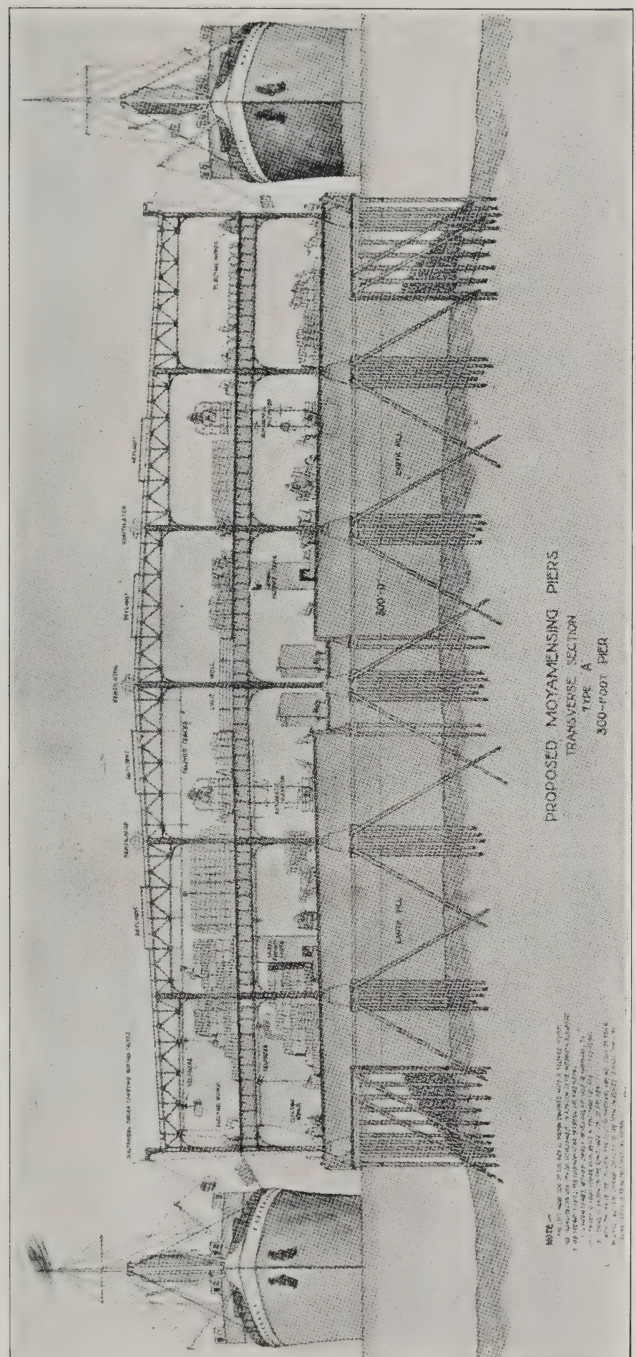
(Photo by author.)

Fig. 39.—Quay at Stavanger. The *Bengensfjord* loading sardines with its own tackle. The quay has no mechanical loading equipment, but rail facilities enable goods to be brought to the ship's side and stacked near the ship's sling.

of the shed will be less than is usual, as there will be one short span only and no intermediate posts to interfere with the freight movements, which posts should be avoided if possible.

It is evident that capacity is secured by height and not by width.

There is one point in which this calculation is open to attack. It is possible to tier standard packages such as bags, bales, and crates of uniform size by well known mechanical means at low



(Courtesy of Dept. of Wharves, Docks and Ferries, Philadelphia, Pa.)

Fig. 40.—Proposed Moyamensing Piers. Type A.

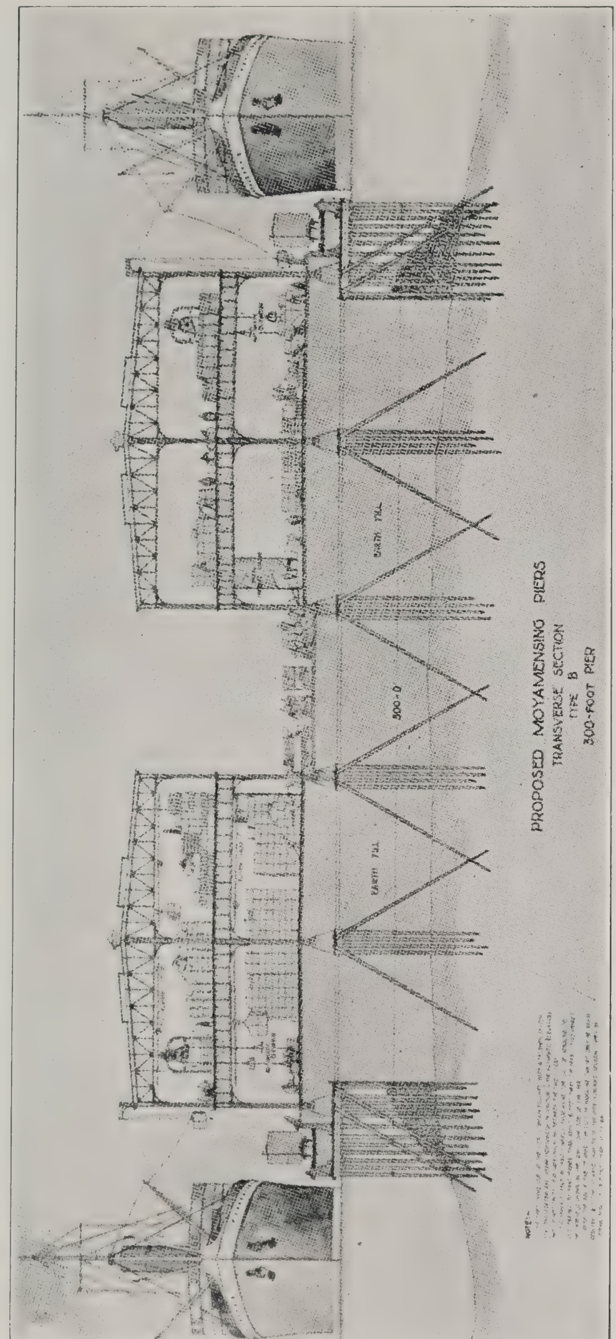
expense. However, it is hardly possible to tier general cargo of all sorts and shapes of parcels except at great expense. Also, it is very difficult to handle small general cargo shipments to scattered consignees when the goods have been tiered. It would therefore seem that, except at wharves handling standardized cargo such as cotton or sugar or coffee in shipload lots for certain large consignees, it would be necessary to build sheds with a large unbroken surface to take the cargo of the usual line traffic spread out and not tiered.

Unbroken Floor Space.—Much of the confusion concerning piers layouts will be avoided by keeping firmly in mind the fact that the pier shed floor as calculated above does not include space for railroad tracks or teamways. The shed is a thing in itself and the relation of cranes, teamways, or railroad tracks to pier design or wharf layout is as an additional part of the equipment and not as part of the shed.

Railroad Freight.—Consider the movement of railroad freight. This constitutes from 50 to 75 per cent. of all the freight movement of most ports serving a prosperous hinterland. In the case of the quay system the spur tracks of the harbor belt railway are the side of the transit shed opposite the steamer. As freight is unloaded onto the deck of the shed it is stored, and as rapidly as cars are available for the shipment the goods are trucked in a more or less straight line across the pier to the cars and loaded. It is seldom very straight across, as the particular car wanted is seldom set directly opposite the particular goods to be loaded. However, as far as possible the movement is across the shed in the shortest possible line.

In case of the narrow piers at New York, the same railroad freight is trucked more or less straight across the pier deck to the lighter which is the substitute for the harbor belt railroad at New York. It would be impossible to berth on each side of the pier at the same time, as the piers do not hold the cargo of one ship as it is. In the case either of the belt line or the lighter the movement across the deck from unloading ship to waiting car or lighter is the shortest possible and most efficient one.

Car Tracks.—The great controversy concerning the placing of car tracks on piers which has aroused so much debate is due to a confusion of very simple principles. In the first place, the idea of putting car tracks down the center of a transit shed located on a narrow pier which, owing to the small width of the pier,



(Courtesy of Dept. of Wharves, Docks and Ferries, Philadelphia, Pa.)

Fig. 41.—Proposed Moyamensing Piers. Type B. (Not executed.)

is already of insufficient area, is out of the question. They are more in the way than serviceable. Then also, if the car tracks do not go to any place, as at New York, they serve no purpose. As long as lighters are doing the belt line service there is no reason for the car tracks.

Much effort has been made to befog the issue of car to ship delivery by stating that the ship can not be loaded from the railroad car. Certain individuals and certain daily papers which should have known better harp on this perfectly true statement. No one loads freight from car to ship even in the great ports of the world where every quay is equipped with car tracks on both the water and the land side of the transit shed, except in case of heavy pieces of certain standardized package or bulk commodities.

Mr. R. A. C. Smith in his testimony in the Lighterage Case gave some pertinent figures concerning the impracticability of loading ships directly from cars. He took a case in point at one of the Chelsea piers. There were two ships berthed at the pier, one a cargo liner of 16,000 tons (it was not stated that she had 16,000 cargo tons capacity) and the other a freighter with 8,000 tons cargo capacity. The larger ship spent the total of five days in port, which is rapid dispatch for such a ship at any harbor. However, it seems quite certain that the ship was a liner and did not discharge 16,000 tons of cargo and load an equivalent amount in five days.

Now, according to the Commissioner, if the ship of 16,000 tons capacity had been loaded from freight cars directly it would have required 480 cars, or a train 19,200 feet long, 3½ miles. If the cars could be marshaled in such manner that there would be no delay in drilling in two rows of eight cars, or 16 in all, it would take 30 shiftings to accommodate 480 cars. The best time that could be made in unloading one set of 16 cars would be four hours, which he considered the utmost speed. It would take 120 hours to unload all the 480 cars. Working all the time, 24 hours of the day, it would take five days to load the ship. As the ship can not load until after it has discharged, it will be seen that allowing half of the time in port for discharging at the same speed as loading it would have taken 10 days to turn the ship around. Therefore the present system would be twice as fast as car-to-ship loading.

The figures seem convincing and they were very convincing to

(From Report of Conn. Rivers and Harbors Commission, 1910.)

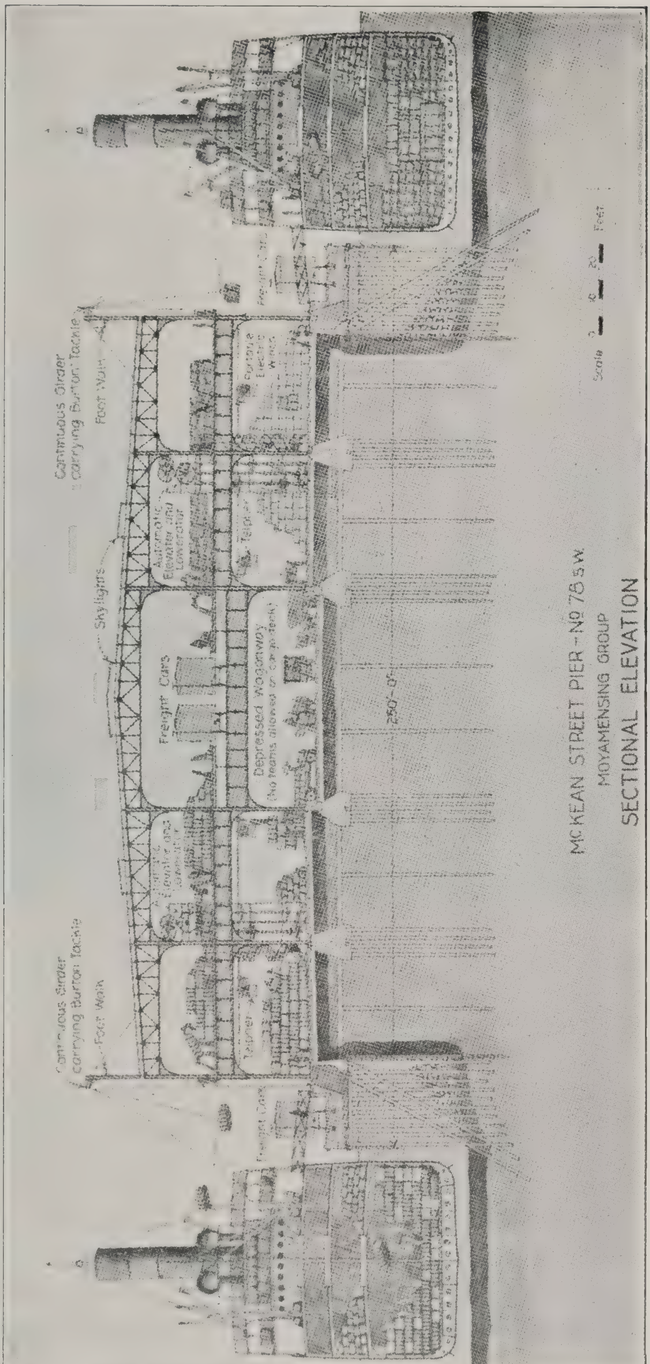
Fig. 42. Cross-sections of typical Hamburg harbors.

most people, and not the least to Mr. Smith himself. What he said is true enough. Yet when one stops to think that at other ports in the world, in particular Antwerp, Rotterdam and Hamburg or Bremerhaven, the practice of car-side delivery is continued at all the new basins after many years' experience, and when it is known that the speed of turning a ship around is at least as great as, usually greater than, at any American port, one sees that there must be something wrong in the reasoning.

As a matter of fact the reasoning is based on a false premise, as is the entire controversy. It is based on the premise that freight is to be transferred *directly* from car to ship. In very few instances is this done. When very heavy pieces are to be loaded the cars are spotted, marshaled, and drilled alongside the ship on tracks situated at the quay edge. Such pieces arrive on gondola cars or on flat cars. Even so, in the case of loading locomotives, boilers, engines, and other similar pieces, the quay cranes of three to five tons can not do the work, and either the ship is moved to one of the 100-ton cranes, or, which is more usual, a derrick lighter floats the heavy pieces alongside from some siding. We may say, therefore, that for heavy pieces, which are not too heavy for the regular cargo cranes, and when delivered in open cars, loading does take place directly from car to ship's hold. Also for bulk freight which is tipped into the hold from the car by a car-hoist or "tipper," such as coal, ore, and sometimes grain, direct loading is possible. These commodities form a small percentage of general cargo and are the exception rather than the rule.

The function of the belt railroad with shipside spurs is not to load from car to ship as a rule. The movement is to save rehandling to lighters or draying from railroad terminal or warehouse to the transit shed.

The loading of belt-line railroad freight is as follows and not as described in the above testimony. The sheds are ample in area with decks not cut up by tracks or teamways. The tracks outside the sheds permit cars to be brought to both the front and back of the shed for unloading *into the shed*. This is done before the ship is ready to load. The function of the shed is to act as a temporary reservoir for the assembling of outgoing cargo so that the cargo may be quickly loaded when the ship arrives. The freight as it is unloaded from cars to the shed is placed according to kind of freight or ports of consignment. The freight is



(Courtesy of Dept. of Wharves, Docks and Ferries, Philadelphia, Pa.)

Fig. 43.—McKean Street Pier. No. 78 S. W.

thus assembled at ship's side from cars which have come unbroken to near the ship's side.

In the meantime the ship has been discharging at another quay reserved for inbound freight. The inbound shed in like manner takes up the cargo as a reservoir pending further disposition. The further disposition is of secondary importance compared to the rapid discharging of the cargo. Once it is lightened the ship is warped across the basin to the loading quay where the freight, properly assembled, may be loaded at a speed limited only by the speed of stowing it in the hold.

Fig. 44.—Pier No. 40, South Delaware Wharves.

It must be added that the shipside car is only of interest when there is the inner belt line and when there is room for tracks on the quay and still room for the proper amount of deck space for working the cargo.

In addition to railroad freight there is a vast amount of freight taken overside, from barges, lighters or heavy-duty derricks. Coal is loaded overside and also grain. Both sides of the ship must be worked.

Therefore, to sum up, the car seldom loads directly to the ship, but usually to the shed for transit storage and for working. The advantage of the car-to-shipside system is that there need be no handling of freight between the point of origin and the

point of unloading at the pier shed. The economy is in this point of the movement and nowhere else.

Location of Tracks.—Where there is no belt line the New York system of moving cargo across a narrow pier to lighters is the equivalent. When there is a belt line and car tracks are run onto the piers the question arises, where to put the tracks. If the tracks are run down the center, the piers at once must be twice as wide because the tracks divide the pier sheds into two separate narrow sheds in which the freight for the railroads is moved across the deck to waiting cars instead of to waiting lighters.

Fig. 45.—Pier No. 40, South Delaware Wharves. Cargo of 3,680 tons of flour on main deck.

Recent American pier design has taken this fact into consideration. Notably at Philadelphia, where the railroad freight is 75 per cent. of the whole, the tracks have been laid down the middle of the pier and the pier made wide enough to leave two separate shed floors, one on either side. Although they are on one pier and under one roof, in fact there are two sheds as far as working cargo in concerned.

In the drawings (Fig. 40) of the new Moyamensing Piers the cross section of Type A shows a total width of 300 feet with the car tracks down the center and two roomy transit-shed floors, one on each side of the track. This system has been used for

some time in other smaller and older municipal piers. Fig. 41 shows Type B with a driveway for teams down the center and the car tracks moved to the outside edge of the pier. The movement would be by tackle hoists over the car tracks to the shed and then into the cars to be shipped by rail from the shed. The driveway for teams has completely divided the pier into two separate units. When the first of the Moyamensing group was built (Spring, 1918), it was given the floor plan of Type B, but on investigation it was found as economical to roof over the entire pier including both pier sheds and carry the upper deck through, as to build the sides of the two sheds. This arrangement gave the teams covering while loading and at the same time added the space of the driveway to the second deck of the pier. Compare Hamburg cross sections, Fig. 42. Fig. 43 shows the McKean Street pier, No. 78, Philadelphia, with its car tracks on the upper deck in the center and on the lower deck with the tracks outside and with the teams in the middle. Fig. 44 shows the cars entering Pier 40. Fig. 45 shows the inside of Pier 40 with the car tracks down the center. At this time 3,680 tons of flour were held on the main deck pending loading. It was tiered rather high, but otherwise it could not have been accommodated.

Teams and Motor Trucks.—The other movement from the pier, after the lighter and the railroad, is by dray or motor truck. This movement, except in the case of railroad freight at Manhattan, is much the smallest of the movements of the cargo.

The congestion on the railroad piers at Manhattan is due to the fact that as it is the piers can not carry sheds of sufficient area to accommodate the freight, and in addition teams and drays are permitted on the piers to load parcels for the consignees. The wide pier, as at Philadelphia, with ample deck room on each side of a roadway would be the solution. With such piers it would be possible to drive to the loading point and receive the parcels from a loading platform of wagonbed height. In this case the car-floats would not be of the platform, 12-car type, but of the 18-car type and therefore more economical. Freight would be unloaded directly to the pier. Congestion would be eliminated because of the free movement of the teams down the center roadway to the point opposite the merchandise to be loaded.

This is not possible on narrow piers which have no provision for teaming space, or on piers whose principal movement is by rail. The solution is to move the freight, by mechanical means

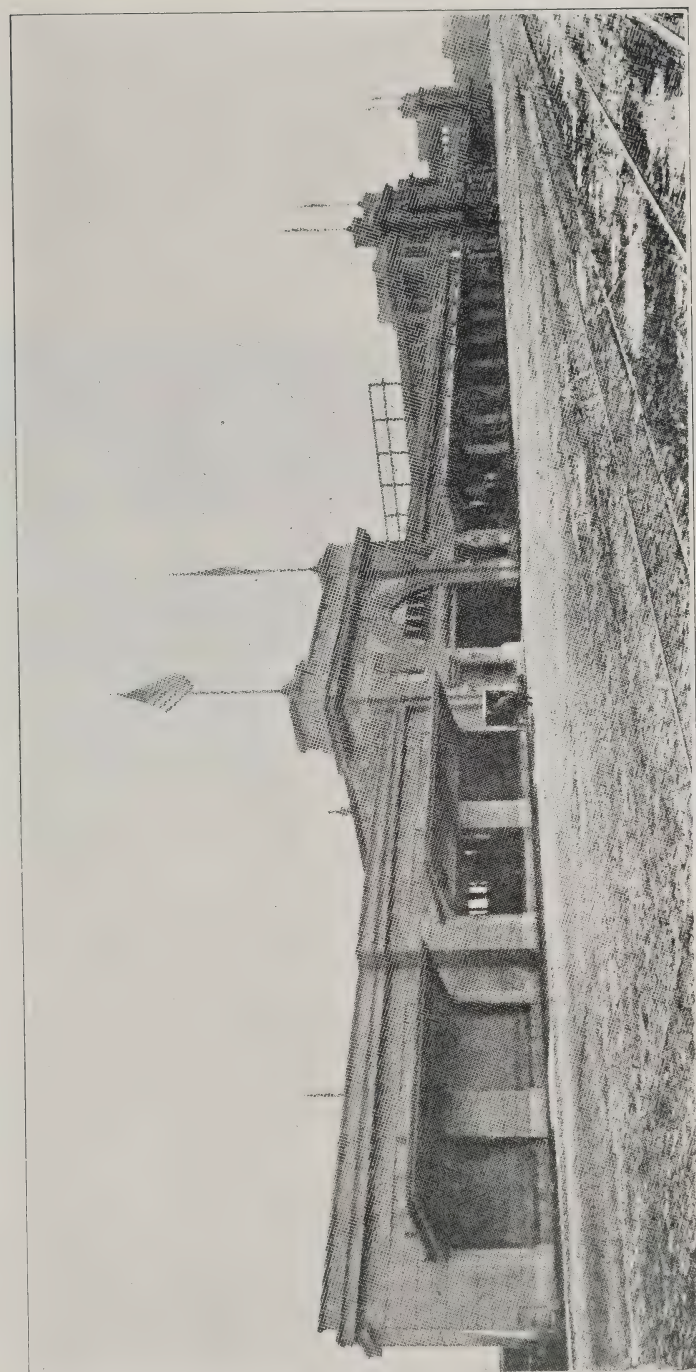


Fig. 46.—Pier No. 36 South Delaware Wharves. View looking south on Delaware Avenue.

if possible, as described in the chapter on carting, to the bulkhead house. This is the building at the entrance to the pier and extending along the bulkhead. This loading platform at the bulkhead should be reached by telpher or electric truck. There should be a loading platform of dray height. This platform is shown at a Philadelphia bulkhead (Fig. 46) and also the electric trucks serving as the connection between the distant pier and the head-house (Fig. 47).

Mr. George S. Webster, Director of Wharves, Docks and Ferries.

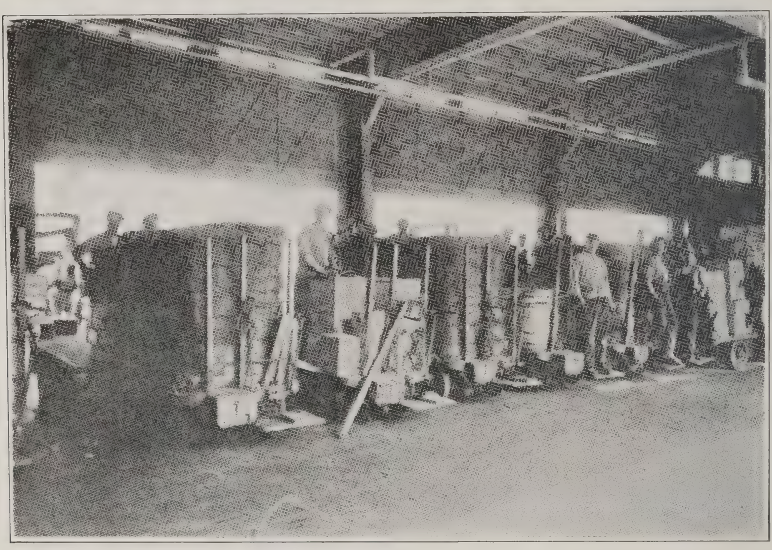


Fig. 47.

Philadelphia, at a meeting of the Engineers Club of Philadelphia, in a discussion on ports, made these remarks:

> The piers as planned (in South Philadelphia, Moyamensing Group) are of ample width to accommodate all business that we believe will come to them. We find that those who handle trucks in the City of Philadelphia have very much less objection to going several miles to a wide pier where there is no congestion and delay than going to a pier immediately on the waterfront where, because of congestion, they may wait for several hours or even an entire day to unload.

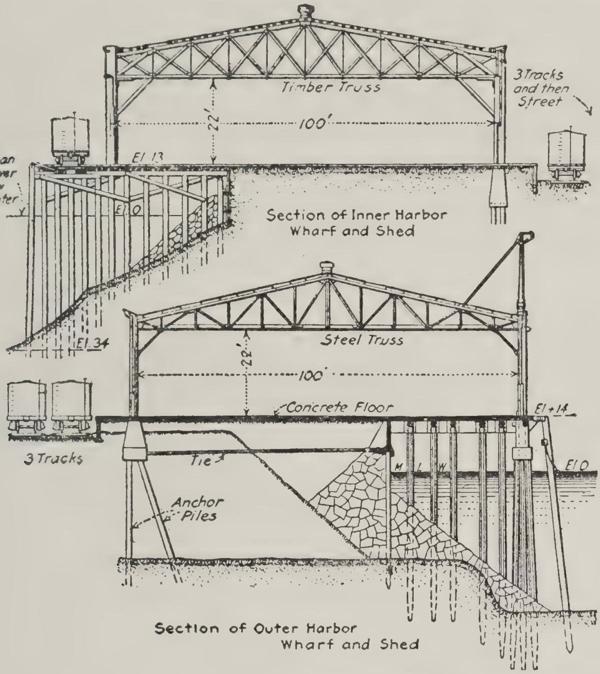
In the case of railroad freight at Manhattan this head-house delivery to drays would be a large job. However, elsewhere, on analyzing the percentage of drayage of *maritime* freight, it is seen to be about 20 per cent. of the whole and this small portion

should by all odds be taken to the head-house rather than have the teams come onto the pier.

At the Bush Terminals the movement of freight is analyzed as follows:[1]

30 per cent. is destined for the warehouse (by means of elevator truck or mule "lorry").

25 per cent. C. L. railroad freight (usually car floated).



(From Green "Wharves and Piers.")

Fig. 48.—Cross-section of a wharf and wharf-shed showing location of car tracks.

25 per cent. L. C. L. railroad freight (usually lightered or car floated).

20 per cent dray for local delivery.

At Hamburg the half of the freight which does not go overside in stream for barge transportation on the interior waterways, but over the quays, has the following distributions:[2]

18 per cent. by rail (C. L. and L. C. L.).

20 per cent. dray to local consignee (or L. C. L. to railroad).

[1] Testimony I. C. C. Lighterage Case.

[2] Clapp, "Port of Hamburg."

45 per cent. by lighter to warehouses or to river express barges.

17 per cent. goes into barges over the quay after the ship has left or over the water side of the ship at the quay.

The Two-Decked Pier.—Contrary to the usual custom in European ports there has been a strong tendency towards the two-decked type of pier-shed construction in America in recent years. There has been the need of more space, the need of keeping incoming and outgoing freight separated without moving the ship, and also the need of economy in waterfront along the congested portions of the cities. As American wharves are not built along artificial basins which can be made to order with the proper amount of upland, the double deck has been the compromise.

Incoming and outgoing cargoes are given separate decks. However, unless there is absolutely the same connection by team and railroad to each deck from the level of that deck, there must

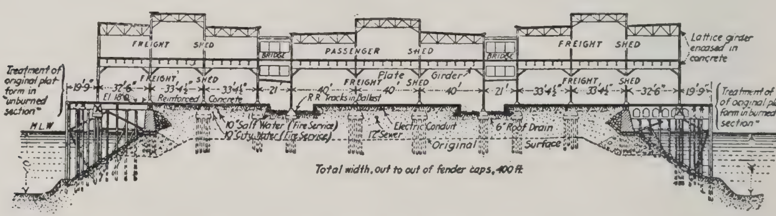


Fig. 49.—Commonwealth Pier, Boston, Mass.

be connection between the two decks. This connection serves to lower the degrees of segregation of in-and outbound freight. It also involves much elevating and lowering from one deck to the other. These movements are accomplished by goods lifts, or ordinary freight elevators, by spiral chutes and by continuous motion parcel elevators. All of these are used on the Philadelphia piers and elsewhere. There is no doubt that this between-decks movement is costly in time and labor. To build outgoing and incoming freight sheds of one story in such relation to each other that the movement of the ship is only a shed length along the pier or quay or a matter of warping across a narrow basin or slip should be encouraged wherever possible.

Length of Piers.—The discussion of the width of piers also involves the question of length. The length of piers depends on the War Department in the United States. At New York and elsewhere 1,000 feet is about the limit allowed, although in South Brooklyn there are piers of 1,700 feet. There are, however, certain considerations of an administrative nature which effect

the economy of length. *The longer the pier the wider it must be.* The reason for this is that the longer the pier is, the more traffic must be handled at the bulkhead end. Its length increases the number of cars and battery trucks which go onto the pier, and if teaming is allowed the longer the pier the more cargo there is and the more teams will be needed.

On the other hand the *wider the pier the longer it must be.* The more waterfront the pier occupies the longer it must be in order to attain the maximum berthing space. There are several things to be considered here.

When a pier becomes longer than 1,000 feet it is uneconomical to move freight by hand or electric truck to the bulkhead for loading into railway cars or drays. When either teams or freight cars are admitted to the pier the space for sorting and handling is greatly reduced. Unless the pier is widened congestion grows rapidly with the length of the pier.

When a pier is longer than 1,000 feet the pier slip must be wide enough to pass large ships beyond a ship berthed near the channel end, but not occupying all the berthing space. The pier and its slips must be of a much greater width as soon as the one ship per slip limit in length has been reached. With accommodation for ships of about 11,000 tons gross, quays or piers would be 500 feet, 1,000 feet, 1,500 feet, 2,000 feet, or some other multiple of 500.

It therefore becomes necessary to depart entirely from the Chelsea type of narrow pier construction and go to another design. The enlargement of the Moyamensing design would give two rows of sheds with teaming and railroads between. Such a pier would be uneconomical of waterfront unless made very long. Once it is made wide it may be made several thousand feet long.

This is only possible where the water is wide and shallow to permit pile-fill structures with dredged deep water between, or a low and soft shore to permit excavation of the slip into the land. At New York the limit on the Manhattan shore seems to have been reached with 1,000- and 1,200-foot piers. At Bayonne or Stapelton Cove, S. I., or at Jamaica Bay piers of a mile in length with a width of 400 feet and slips of the same width or more are not only possible but urgently desirable. If a pier or quay is more than a mile in length and used for passenger service there should be street car connection with the town. The long European basins are made accessible to people having business in various parts of the harbor by small steamboats.

PIERS

Name and location of pier	Length (feet)	Width (feet)	Width of slip (feet)	Type piles filled	No. of railroad tracks	Profit
Pier 36, Clyde S. S. Co.	1,003	75	--------	Piles		
Pier 59	825	125	--------	Piles		
Bush Pier 6 Bush Pier 4	1,241 1,335	270 150	--------	Piles	------------	2 story
San Francisco, cost $3.50 p. sq. ft. of deck	222 555 720 807	Pier 200 Shed 156	--------	Piles	1 track	
Chicago Municipal Pier	3,000	292 Sheds 100	--------	Solid fill	Street R. R. 4x	2 story
South Brooklyn	1,745	175 Shed 140	--------	------------	2 track outside	
56th Street, New York	1,000 Shed 921	------------	--------	Piles	2 above 2 below sunken	Load 500 lb. 300 lb. 50 lb.
Havana, Cuba (2)	680	164	262½	Concrete piles	2 tracks 2d floor	2 floors, concrete
Philadelphia Touchwark South (4)	550 Ca. 600 Ca. 7,000	180 250 300	200 250 300	Piles and fill	2 center Main deck Main deck	Load 600 lb. 2 decks 2 decks 2 decks
Commonwealth	1,000	400	--------	Piles, solid fill	6 tracks	3 sheds 20 ft. margin
Halifax (4)	693	Pier 235 Shed 200	--------	------------	2 middle 1 each edge	Loads 1,000 500 100

GENERAL ORLANDO M. POE

By

Lieut. Chas. C. MacLeod

Engineer, U. S. A.

Among successful military men who gained considerable prominence in civil life, the name of General Poe commands an exalted, well earned position in our national history.

Orlando M. Poe was born at Navarre, Stark County, Ohio, March 7, 1832. He received his early education in the public schools of Navarre County, later attending the Canton Academy, at Canton, Ohio, for two years. Early in life he had determined on a military career, but he encountered numerous difficulties in getting an appointment to the military academy. He was graduated sixth in the class of 1856 at West Point, receiving a rank of Brevet Second Lieutenant, Topographical Engineers, July 1, 1856. Some of his associates at the academy were men who gained considerable distinction during the Civil War.

While a Brevet Second Lieutenant, Poe served in the capacity of instructor at West Point. He was given full rank of Second Lieutenant, October 7, 1856, and served under Capt. George G. Meade, in astronomical and other work, in connection with the survey of the Great Lakes, receiving his commission as a First Lieutenant, July 1, 1860.

During the winter of 1860-6, Poe realized the fast growing trouble between the North and the South, and wrote to Governor Dennison, of Ohio, placing his services at the disposal of his state executive. The day hostilities commenced at Fort Sumter, Governor Dennison sent for Poe, and although granted but one week's leave, he materially assisted in organizing the first Ohio regiments which went into the field. He was offered the command of the Ohio troops but was forced to decline it, as the War Department still clung to the hope that the regular army might be held together. At Poe's suggestion, George B. McClellan, then in civil life, was placed in command of the Ohio troops. Lieutenant Poe served on

McClellan's staff as Chief Topographical Engineer from May 13 to July 15, 1861, and in Washington from July 26 to September 26, 1861.

On September 16, Lieutenant Poe was appointed a Colonel of the Second Michigan Volunteers, and continued in that rank to February 16, 1864. He served immediately after his appointment and to March 17, 1862, in command of a regiment in the defense of Washington, and in the Virginia peninsular campaign from March to June, 1862, taking part in the siege of Yorktown, April 5 to May 4; in the battle of Williamsburg, May 5, and of Fair Oaks, May 31, where he had a horse shot from under him. At the second battle of Bull Run he commanded a brigade, and also at the battle of Manassas, August 29 and 30. He was in the Maryland campaign from October to November, and on November 29, 1862, was nominated by President Lincoln to be a Brigadier-General, and served in that rank up to March 4, 1863. He was in the Rappahannock campaign, December, 1862, and in the battle of Fredericksburg, December 13, and commanded a division of the Ninth Army Corps, February 16 to April 11, 1863, taking part in the movement to the Department of the Ohio, March 17, 1863.

His nomination as Brigadier-General, with a number of others made at the same time, was not acted upon by the Senate, for the reason that no provision for the necessary increase of officers had been made by Congress and no vacancies existed. Having resigned his post as Colonel in the Michigan Volunteers, at the time of his appointment as Brigadier-General, he found himself, for a brief period, out of the volunteer forces and in his old rank of Lieutenant of Engineers in the Regular Army. He was urged by his Michigan comrades to return to the command of his regiment, but he declined, for the reason that it would interfere with the promotion of the other officers.

Soon afterwards, he was appointed Chief Engineer on the staff of General Burnside, participating in the march to East Tennessee and the occupation of Knoxville. He was in action at Blue Springs, October 10, and in the defense of Knoxville, November 18 to December 4, 1863.

Poe served as Assistant Engineer, December 15, 1863, to April 3, 1864, and Chief Engineer, April 3, 1864, to June 29, 1865, of the Military Division of the Mississippi; in the invasion of Georgia, May 2 to December 21, 1864, being engaged in demonstrations

against Dalton, May 7, 14; battle of Resaca, May 15; action of Adairsville, May 17, and of Kingston, May 19; battle of New Hope Church, May 20; battle of Dallas, May 25, 28; movement on Kenesaw, May 28 to June 20; battles of Kenesaw Mountain, June 20 to July 2; assault on Ruff's Station, July 4; movement upon Atlanta, July 22 to August 25; battle of Jonesborough, August 31; erecting new defenses at Atlanta, September 4 to November 16; march to sea from Atlanta to Savannah, December 21, 1864, to January 23, 1865, being engaged in the battle of Averysborough, March 16; battle of Bentonville, March 20, 21; capture of Raleigh, April 13, and surrender of the Rebel army under Gen. Joseph E. Johnston at Durham Station, North Carolina, April 26, 1865. He was breveted a Major, July 6, 1864, after the siege of Knoxville; a Lieutenant Colonel, September, 1864, upon the capture of Atlanta; a Colonel, December 21, 1864 following the capture of Savannah; and, finally, a Brigadier-General March 13, 1865, for gallant and meritorious services in the campaign terminating with the surrender of the insurgent army under Gen. Joseph E. Johnston.

General Poe, during his association with Sherman, in the invasion of the South, formed a lasting friendship with him which did not terminate with the war. Each regarded the other very highly and Poe openly expressed himself when he claimed that Sherman was the greatest soldier the Civil War produced. Sherman's high opinion of Poe was expressed when he said some years later, "I consider him (Poe) one of the most accomplished officers in the army. If I should die tomorrow he is perfectly capable of filling the place I occupy." When General Sherman was made General of the Army he selected Poe to represent the Engineer Corps on his personal staff with the rank of Colonel, in which capacity he served until 1883.

After retirement from active service in 1883, General Poe possibly attained the pinnacle of his usefulness to the nation. He was an expert on the improvement of inland waters, rivers and harbors, and notable examples of work done under his supervision are much in evidence in the Great Lakes district.

He had charge of the construction of St. Mary's Falls Canal, which included one of the largest canal locks in the world. The work of improving the Hay Lake Channel, the St. Claire Flats Canal, and the Detroit River at Lime Kiln Crossing was under his supervision. The improvement of the harbor of Cheboygan, at

Thunder Bay, the Saginaw River, The Ice Harbor of Refuge at Belle River, and many other river and harbor works were all under Poe's direction. In 1888 he began the improvement of Grosspoint Channel, which was transferred to the ship channel in 1892, and in that year work was begun on the ship channel connecting the waters of the Great Lakes between Chicago, Duluth and Buffalo.

As a member of the Light House Board, General Poe also gave the nation lasting memories of his labors. His total service in this branch of engineering extended over a period of eighteen years. The lights at Spectacle Reef and Stannard's Rock are among the big light projects supervised by Poe.

In 1892 the Inspector General of the Army said of his work on the Great Lakes: "The magnitude of the work and the intricacy and precision of detail was a revelation to me. I could find in the methods adopted by Colonel Poe, as applied to the works under his charge, and his personal knowledge and control of the details, nothing wanting in thoroughness and efficiency. I cannot close without referring to the great responsibility resting upon the shoulders of this officer, a responsibility of a character which cannot be well understood or appreciated, except from a personal knowledge of the details of this great work."

About the middle of September, 1895, General Poe was called to Sault St. Marie, Michigan to examine a break in one of the locks, and while making the inspection slipped, causing an injury to his left leg, which developed into erysipelas and resulted in his death on October 2, 1895.

The expressions of sorrow which followed were universal and the eulogies which appeared in the public press showed the appreciation in which he was held because of his public services and private worth.

It is believed by many who knew Poe personally that sorrows within his own home hastened his death at a period when he seemed to be enjoying the benefits of careful living. Two deaths in hurried succession among his children, of whom he had three, deeply grieved him and left him sincerely devoted to his family's loss and comfort.

Viewed from a military standpoint, General Poe's career was successful and full of interesting work. His later success in civil life shows him to have been a finished man, capable of accomplishing every undertaking with a thoroughness which was distinctly charac-

teristic. He possessed a keen sense of duty to his home and country, sacrificing at one time an opportunity to be military attaché for the United States Government during the Turco-Russian war because of his family, and declining several important positions in civil life because he thought he owed his country his experience and knowledge. He was of dauntless courage, morally and physically. His opinions were formed carefully and based on knowledge, and once reaching a decision he never deviated from it. Political participation he thought unbecoming an officer, but he took a keen interest in all national events.

Poe was a born mathematician and possessed a mind of remarkable accuracy. His nature was large, his views liberal, and the sentimental side of life was highly developed in him.

NOTES ON THE FIELD EMPLACEMENT OF A GERMAN LARGE CALIBER GUN.

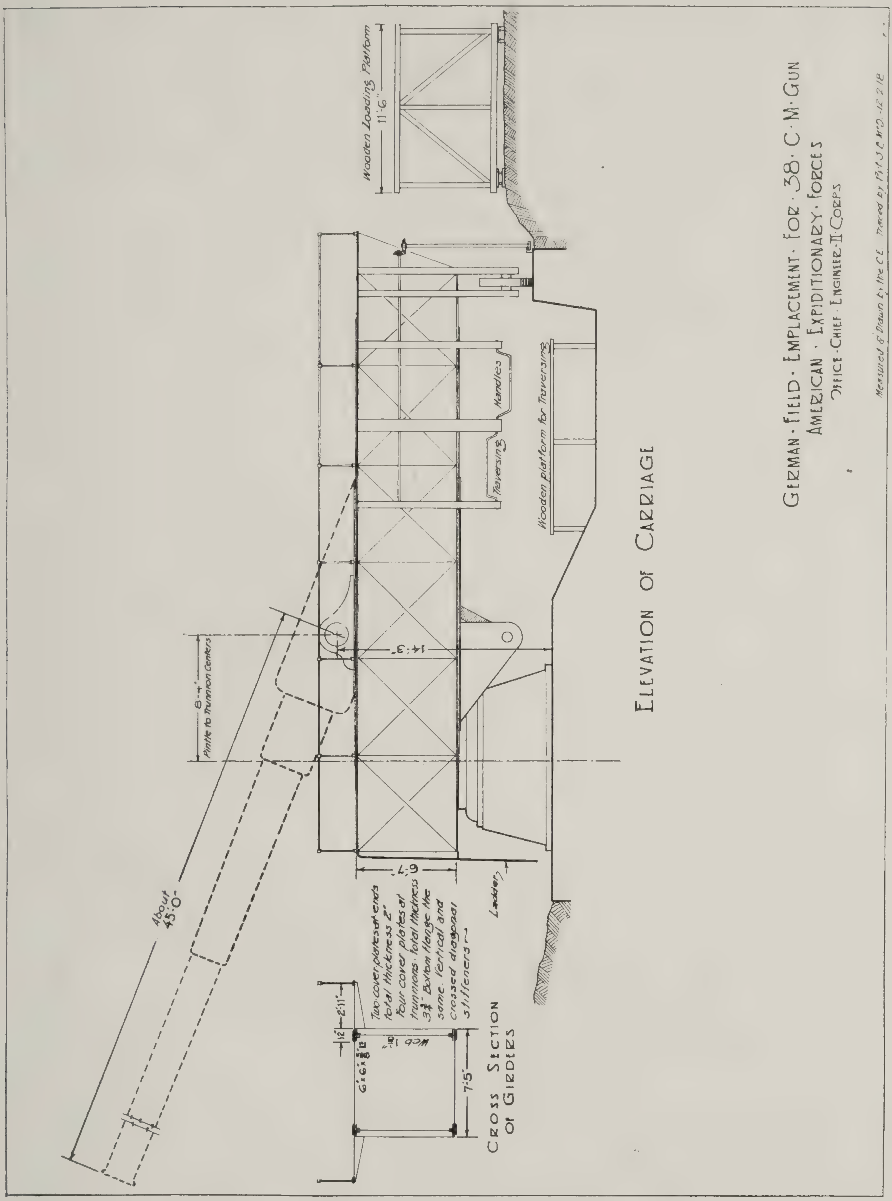
By

Col. G. B. Pillsbury
Corps of Engineers; II Corps, A. E. F.

During the Spring of 1918, the Germans pushed their advance to within some 10 miles of the important railroad center of Amiens. They emplaced a 15-inch gun at a point 20 miles east of the city for the purpose of its bombardment. In their subsequent retreat the emplacement was captured by Australian troops, who found the gun demolished and the carriage wrecked, but the foundations intact. The writer recently had an opportunity to make a very careful examination of the emplacement and found much which may be of interest.

The Gun. The gun was of 38-centimeter caliber. A portion of the chase, 40 feet in length, was lying in front of the carriage, the breech was utterly demolished. A section of the muzzle, length unknown, had been cut off as a trophy. From the position of the portion remaining and the length of the carriage, it is safe to say that the length of the gun was certainly over 60 feet, and less than 80 feet. I would judge that the total length was 50 calibers. The breech block, lying some 100 yards in rear of the gun, was of the Krupp type, with a very simple translating screw. The end of the breech, back of the block, was found intact some 400 yards in rear of the emplacement. The aperture was about 19 inches in diameter, thus fixing the superior limit of the diameter of the powder chamber. In construction the gun was of the ordinary built-up type. It very evidently was mounted in a recoil cradle which swung on trunnions on the carriage.

The Carriage. The carriage was of the front pintle type. It was formed of two parallel plate girders, connected in front and rear by transoms, and supported in front on heavy forged steel plates resting on the pintle bearing, in rear by heavy legs carrying the traversing wheels. The cradle trunnion blocks and the traversing and elevating mechanisms were, of course, mounted on these girders.



Elevation of carriage.

The girders of the carriage were 6 feet 7 inches in depth and about 41 feet in length. The web was a 1⅛-inch rolled steel plate. The flanges were about 13 inches in width, of 6 by 6 by ⅝ inch angles with about 1 inch cover plates, the total flange thickness, exclusive of the angles, being 2 inches at the ends and 4 inches at the trunnions. Web stiffeners were spaced at intervals about equal to the depth of the girder, and diagonal stiffeners crossed the panels so formed. The girders were evidently shipped to the site completely assembled and connected.

The pintle bearing rested on a cast pedestal, some 11 feet in diameter. The mechanism included a ball bearing, formed of balls 6 inches in diameter separated by a bronze distance ring, surrounding a very massive forged steel pin which took the recoil. The holding-down device by which the carriage was prevented from jumping off the pin was not accessible, at is was enclosed in a box formed by the front transoms.

The traversing wheels were 3½ feet in diameter and 8¾ inches in breadth.

The cast steel trunnion blocks of the recoil cradle rested on and were bolted to the upper flanges of the main girders of the carriage. The trunnion bearings were 18 inches in diameter, with a 13-inch face.

Enough of the parts of the recoil cradle were lying about to indicate quite clearly that the recoil mechanism included one hydraulic buffer cylinder, 16½ inches in interior diameter and 5 feet 5 inches long, and two return spring cylinders. One may infer that the recoil was limited to about 4 feet.

The carriage was traversed by a toothed wheel engaging on a rack bolted to the rear of the traversing circle, this wheel being actuated through shafts and gearing by an electric motor, or by auxiliary hand cranks on which eight men could easily be placed, four on each side of the carriage.

The elevating mechanism was very substantial and compact. The elevating screw was 14½ inches in diameter, and passed through a heavy cast box swung on trunnions from the carriage. These trunnions were hollow, and each carried a central shaft by which the elevating screw nut within the box was turned by bevel gearing. The elevating screw had apparently been pivoted to the cradle, but the connection was entirely destroyed. The elevating mechanism was operated by an electric motor with auxiliary hand cranks.

The carriage was provided with a walkway on either side bracketed at the level of the top of the girders, access to which was afforded by steel ladders.

The Foundation. The foundation for the carriage was formed wholly of structural steel and forged plates. No concrete was used.

The pintle block was 19 feet square and 6 feet deep. It was formed of two box girders, 8½ by 19 by 6 feet deep, placed side by side and bolted together, connected at the bottom by a forged steel plate, or plates 3 inches in thickness which extended over the entire area of the foundation, and on top by a plate of the same thickness, 12 feet 10½ inches square. The débris in the bottom of the pit made it impossible to ascertain whether or not the bottom plate was one piece; but it may be assumed that the transportation by rail of a plate 19 feet square was impossible, and that two plates were used, the box girders and longitudinal and transverse diaphragms dividing them into cells about 3 feet square in plan. The top flange of the girders was formed of three ⅝-inch plates, the bottom flange of two ⅝-inch plates. Angles, 6 by 6 inches by ⅝ inch, were employed throughout at all intersections. There were four holding-down bolts 2 inches in diameter at the bottom of each cell, by which the girders were connected to the bottom plate, and each of these bolts had a lock-nut or cotter pin. Manholes through the diaphragms afforded access to the interior of the girders. One side of the pintle block carried two massive steel hooks for service in mounting the gun.

The traversing circle was a quadrant in extent and had an outside radius of 34 feet. It was formed of two layers of forged steel plates, in segments 14 feet long, breaking joints, and supported by a curved box girder, 7 feet 3 inches in depth, formed of segments of the same length bolted together. The upper course of plates had a thickness of 4½ inches, the lower 1¼ inches. Under the box girder there was a similar single course of forged plates 3 inches in thickness. The supporting girder had diaphragms spaced at 2-foot 4-inch intervals, which were continued beyond the girder on the inside, to form triangular ribs.

The pintle block was connected with the traversing circle girder by four box girders, 4 feet 3 inches in width, with top and bottom flanges of the same thickness as the flanges of the pintle block. These girders had cross diaphragms, but no longitudinal diaphragms. There were no base plates under these connecting girders, each of which was evidently shipped as one piece. The con-

necting girders were not placed radially, but the end of each, from a point about 5 feet from its junction with the traverse circle girder was turned in a radial direction. The junction of each girder with the traverse circle girder was reinforced with a structural steel box.

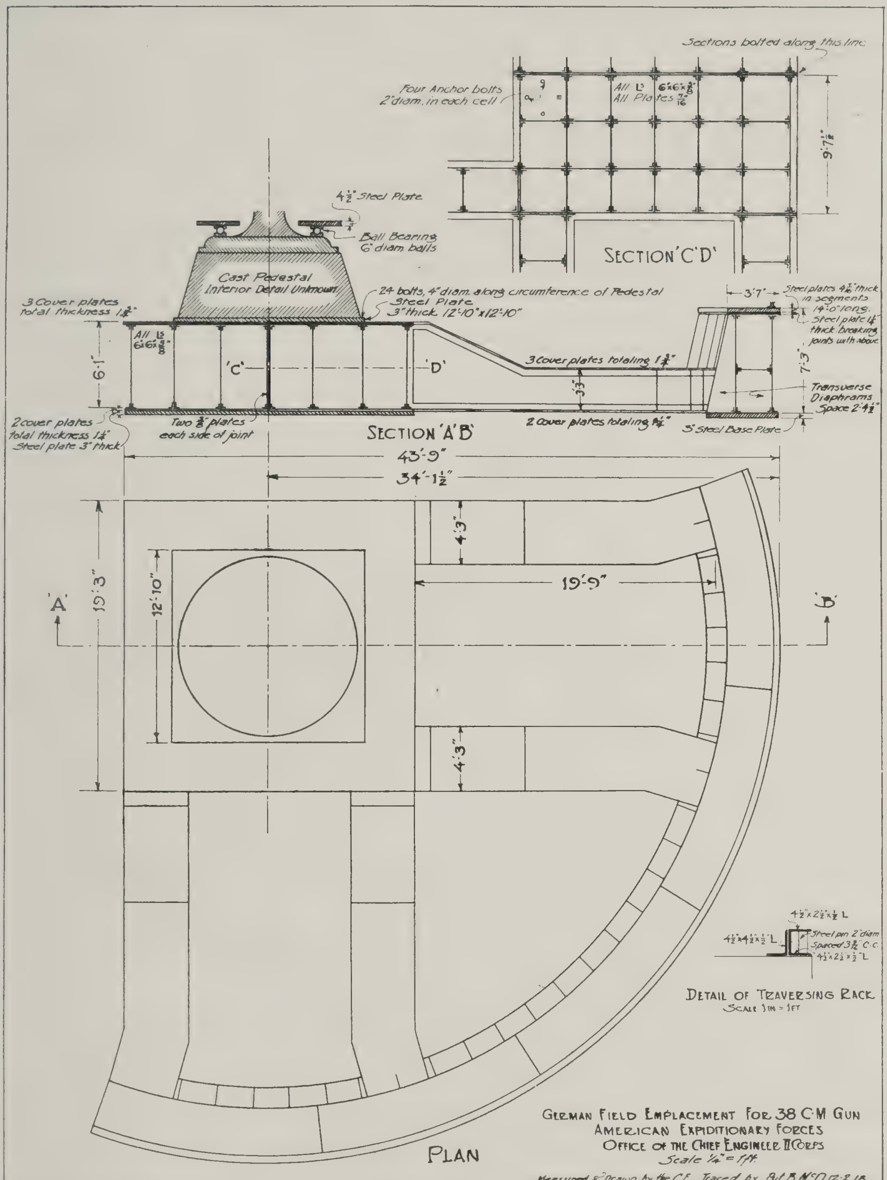
The foundation for the gun had been prepared by excavating a pit of the required horizontal dimensions, about 7 feet deep, and bringing to the bottom to a level with available railroad ballast, which happened to be of rather inferior quality. Three lines of standard gauge railroad, consisting of a central stub, with a spur on either side (at 18-foot centers) had been laid, and the parts, one may surmise, had been placed directly from the cars, possibly by a wrecking crane.

No means whatever were provided for levelling the fixed parts of the structure. Their level must have depended entirely upon the initial levelling of the sub-base. The traversing mechanism was, however, sufficiently powerful to easily traverse the piece even if it were considerably out of level.

There were no signs of overstrain in any part of the foundation structure. The workmanship was of exceptionally high grade and finish.

The Ammunition Supply. A curved wooden platform, 11½ feet in width, supported on trestles, had been constructed just in rear of the traversing circle, at the proper height for the delivery of projectiles and powder charges by hand trucks to the breech of the gun. A hinged flap of the carriage extended the platform to the breech. This platform was reached by a wooden ramp, on a slope of possibly 1 on 7. There were six or seven ammunition trucks lying about. The tray on these trucks was 9 feet 9 inches in length. They ran on two wheels, with a pivoted castor in rear. The ramp leading to the loading platform was provided with tracks for the wheels, with a light U-central track for the castor. A branch track at the bottom of the ramp led to a wooden loading table at the proper height for rolling a projectile on to a truck.

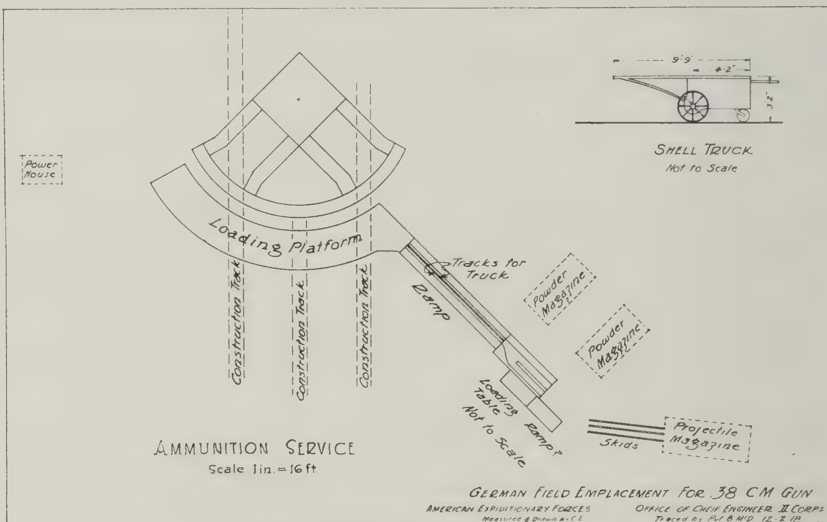
Just how the projectiles were gotten on the loading table is by no means clear. Only one end of the loading table was standing at the time of the inspection, and this end showed no signs of the wear the rolling of heavy projectiles would have caused. It may, however, have been covered by a steel plate when in use. One may infer, however, from the pieces lying about, that the projectiles were rolled up on to the table on an incline at the end.



Plan of carriage.

Close to the loading table there was a shelter sunk in the ground to the roof level, and covered with a roof composed of one layer of railroad rails and one layer of heavy timbers. This shelter had a capacity for possibly one hundred projectiles. Longitudinal skidways led down the inclined entrance to the magazine. A narrow-gauge spur track, with a flat car, ran from the standard-gauge track to the entrance.

It seems probable that the projectiles were transferred from the standard gauge track to the flat car, and run to the shelter, where the shipping crates were removed, and the projectiles rolled down the skids in the magazine. As required, they were apparently rolled up the skids and on to the loading table, thence by the ammunition tracks to the gun.



Ammunition carriage.

There were two similar shelters alongside the base of the ramp which apparently were used for the storage of powder charges. These seem to have been carried by hand to the trucks.

There was a gasoline-driven generating set, of perhaps 10-kilowatt capacity, installed near the gun in a similar shelter, for furnishing power for the traversing and elevating motors. Another shelter provided limited accommodation for the gun crew.

None of these shelters were proof against a direct hit by heavy artillery, unless, at least, the projectile had an instantaneous fuse.

They afford, however, good protection against airplane bombs, which after all is what the gun had principally to fear.

Concealment. The gun was located in a patch of woods on the reverse slope of a hill. Whatever camouflage was used was destroyed by the explosion of the gun, or removed. Branches had been tied on the loading platform to conceal its outline. There was considerable camouflage material lying in the ditches of the railroad tracks leading to the emplacement, and these may have been covered by this material when the emplacement was in use.

Comments. The gun may, of course, have been any naval or seacoast gun. From the similarity of the character of construction of the gun carriage and foundation, and from the evident fact that the latter would never have been built of structural steel if time had permitted the placing of concrete, it would appear certain that the carriage was specially constructed for field use.

The original plan had evidently been to sink the emplacement to such depth that ammunition could be delivered to the breech at or about ground level, for the carriage contained bearings for the traversing wheels at a suitable height for that purpose. The high legs supporting the rear of the carriage were of different and less finished construction, and were evidently added as an afterthought.

It has been said that the gun was only fired five or six times before it was destroyed by an accidental explosion. This is evidently an error, for there were a large number of discarded projectile crates in the vicinity of the magazines, while no unused projectiles were left behind. Moreover, the position in which the breech block and breech end were found, far in rear of the emplacement, taken with the circumstance that the elevating screw was left nearly or fully extended, indicates very clearly that the gun was in a horizontal, if not a depressed position, when the destruction took place. One would say that the chamber had been loaded with high explosive behind tamping in the barrel.

Just why electrical power was applied to the traversing and elevating mechanism when the ammunition service must have required a very heavy force of men, is difficult to say, but this circumstance, together with the fact that the emplacement was surrounded by an utterly useless belt of wire entanglement, possibly indicates that in such details our enemy is no more infallible than ourselves.

Book Review.

Ports and Terminal Facilities. By Roy S. MacElwee, Ph. D. McGraw-Hill Book Co., New York City. pp. viii, 315. 23 cm. $3.00. Illustrated.

This volume consists of a collection of lectures on "Ports and Terminal Facilities" given at the School of Business, Columbia University. The author's purpose is to point out some of the factors which enter into the problem of efficient ports and to stimulate the investigation, study, and analysis of port problems.

Dr. MacElwee presents the nature of the problem and then discusses the relative importance and physical characteristics of the world's leading ports. In order to have a definite basis for discussion, he constructs, in outline, an imaginary port. The relation of railways to seaports is next considered and then each element of the port itself is taken up. A very interesting chapter on "Inland Waterways and the Seaport" follows this, and a consideration of the free port as an institution closes the book. Such features of the problem as finance, dues and income, the combination of beauty with utility, port administration, and the legal aspect of riparian rights are reserved for possible second volume.

The book will be appreciated by all those who are interested in the broader economic aspect of the problem of efficient ports. It should also give engineers and port officials, business men, and progressive citizens a better understanding of the importance of the subject.—J. H. E.

Editorial Note.

The publication of this number has been delayed by the many changes incident to the demobilization of the Army.

AERIAL PHOTOGRAPHY.

BIBLIOGRAPHY OF AVAILABLE MATERIAL RELATING TO THE MEANS, METHODS, EXPERIMENTS AND RESULTS OF AERIAL PHOTOGRAPHY. PREPARED IN THREE PARTS, EACH PART WITH AN INDEX, BY MR. H. E. HAFERKORN, ENGINEER SCHOOL LIBRARY, WASHINGTON BARRACKS, D. C., APRIL-MAY, 1918.

TABLE OF ARRANGEMENT.

PART II.

BALLOON-PHOTOGRAPHY, INCLUDING KITE-PIGEON-ROCKET-CAMERAS.

PREFATORY NOTE.

It was deemed practical to add the call-numbers to titles of books in the Library of Congress, as far as the same could be learned in the space of time allotted to the preparation of this Bibliography.

Material not available in Washington, but listed in certain libraries in New York City, has been supplied with the following initials, or abbreviations, viz: CC. E. and N. Y.., at the end of each title.

Titles to which no initials are affixed have not been located in libraries available to us, but have been included in the list on account of their importance.—H.

ABBREVIATIONS.

The initials at the end of titles refer to libraries where the publications will be found, viz: AW; Army War College Library, Washington, D. C.; CC: The Chemists Club Library, 55 East 41st St., New York; E: Library of the Engineering Societies, 29 W. 39th St., New York; ES: Engineer School Library, Washington Barracks, D. C.; GS: Library, U. S. Geological Survey, Washington, D. C.; LC: Library of Congress, Washington, D. C.; NM: National Museum Library, Washington, D. C.; PO: U. S. Patent Office Scientific Library, Washington, D. C.; WB: U. S. Weather Bureau Library, U. S. Department of Agriculture, Washington, D. C.

A. C. A. M.: Annales conservatoire des arts et métiers, Paris.

Acad. Sci.: Académie des sciences, Paris. Comptes rendus hebdomadaires des séances de l'Académie des sciences.

L'Aéro: L'Aéro, Paris.

Aër. Club: Aero-Club Suisse. Schweizerischer Aero-Klub, Bern. Bulletin. (In both German and French).

Aeron: L'Aéronautique, Paris.

L'Aéron: L'Aéronaute, Paris.

Aeron. J.: Aeronautical Journal, Londan.

Aeron. W.: Aeronautical World, Glenville, Ohio.

L'Aéroph.: L'Aérophile, Paris.

A. G. I. P.: Annuaire général et international de la photographie, Paris.

Am. Aeron.: American aeronaut and aerostatist, St. Louis, Mo.

Army N. G.: Army and Navy Gazette, London.

A. Scient. I.: L'Année scientifique et industrielle, par Louis Figuier, Paris.

Av.: Aviation, New York.

Brit. J. P.: British journal of photography, London.

Cent. M.: Century magazine, New York.

Conq. L'Air. La Conquête l'air, Bruxelles, Belgium.

Cosmos: Cosmos, Paris.

D. Luftf. Z. B.: Deutsche luftfahrer zeitschrift, Berlin.

D. Off.: Deutsches offizierblatt, Berlin.

D. Z. L.: Deutsche zeitschrift für luftschiffahrt, Berlin.

Fly: Fly, Philadelphia, Pa.

Flying: Flying, New York.

Génie C.: Le Génie civil, Paris.

Illus.: L'Illustration, Paris.

Illus. aer. M.: Illustrierte aeronautiche mittheilungen, Strassburg.

Illus. L. N.: Illustrated London News, London.

Illus. W. N.: Illustrated war news, London.

Int. Arch. P.: Internationales archiv für photogrammetrie, Wien. Verlag, Carl Fromme.

Kosmos: Kosmos, Stuttgart.

Mar. C. Gaz.: Marine Corps gazette, Washington, D. C.

Mittheil. G. A. G.: Mittheilungen über gegenstände des artillerie-und geniewesens, Wien.

Nature, L.: Nature, London.

La Nature: La Nature, Paris.

Petermanns M.: Dr. Petermanns mittheilungen aus Justus Perthes' geographischer anstalt, Gotha.

Photo-Min.: Photo-Miniature, London and New York.

Photo. T.: Photographic times, New York.

Photog. M.: Photographische mittheilungen, Berlin.

Photog. N.: Photographische nachrichten, Berlin.

Photog. W.: Photographisches wochenblatt, Berlin.

Prof. M.: Professional Memoirs, Corps of Engineers, and Engineer dept.-at-large, Washington Barracks, D. C.

Prom.: Prometheus, Leipzig.

Rev. l'Aér.: Revue de l'Aéronautique, Paris.
Rev. du G. M.: Revue du génie militaire, Paris.
Rev. G. S. P.: Revue générale des sciences pures et appliquées, Paris.
Rev. Scient.: Revue scientifique (Revue Rose), Paris.
Sci. Am.: Scientific American, New York.
Sci. Am. S.: Scientific American Supplement, New York.
Science V.: La Science et la vie, Paris.
Soc. Aer Ital.: Societá aeronautica italiana, Rome. Bolletino.
Soc. F Phot.: Société française de photographie, Paris. Bulletin.
Spect. M.: Le Spectateur militaire, Paris.
Umschau: Die Umschau, Frankfurt, a. M.
La Vie S.: La Vie scientifique, Paris.
Wien. L. Z.: Wiener luftschiffer-zeitung, Wien.
Zeit. L.: Zeitschrift für luftschiffahrt, Berlin.

A. Books and Separate Impressions.

1 BATUT, ARTHUR.
La photographie par cerf-volant. Paris, Gauthier-Villars, 1890.
74 p., incl. figs., plates. 23cm.

2 BERGERET, ALBERT.
Les récréations photographiques. Par A. Bergeret et Felix Drouin. 2e édition, revue et corrigée, avec 4 planches hors texte, tirées en phototypie et 131 gravures dans le texte. Paris, Charles Mendel, 1893.
224 p. 131 figs., 4 pl., 24cm.
Has chapters on balloon photography, and on photographing by means of kites.

3 CHAUMONT, H.
Détermination des objectifs dérobés aux vues au moyen du ballon captif. Par Lieut. H. Chaumont. Paris, Berger-Levrault, 1909.
70 p., incl. 20 figs. 23cm.
Determination of concealed objectives by means of the captive balloon.
Shows methods by which telephotography from a captive balloon can enable siege artillery to fire on concealed targets. Author explains his own methods of fixing on map the object disclosed by a photograph taken from a captive balloon. He discusses, with diagrams and mathematical calculations, various cases. Then he explains how telephotography can show the elevation of an object. Finally he points out that only an artillery officer can observe artillery fire, so that artillery officers must be trained in balloon work and telephotography.

4 DOLEZAL, EDUARD.
Ueber photographische ballon-aufnahmen und ihre verwendung. Vortrag gehalten 12. Januar 1910, in Verein zurvebreitung naturwissenschaftlicher kenntnisse in Wien. Vorträge. [Aus schriften des vereins]. Wien, W. Braumüller, 1910. 50. jahrg., 13. heft, 30 pages, 10 plates, 23cm.
LC[?] (Q44 V6, v. 50)

5 GODY, LEON.
La photographie appliquée aux arts militaires et aux arts civils. Leçons théoriques et pratiques. Namur, Wesmæl-Charlier, 1890.
212 p., incl. figs. 23cm.

Chap. 7. Applications militaires et scientifiques de la photographie, p. 238.—Photographie en ballon, p. 239.

The second edition of this book was published ib., 1901.

6 Grahame-White, Claude.

The aeroplane in war. By Claude Grahame-White and Harry Harper. Philadelphia, Pa., J. C. Lippincott co. Lond., T. Werner Laurie, [1912]. LC (UG630G7)

Printed in Great Britain.

Chap. iv. Photography from a war aeroplane.—The use of special automatic cameras, p. 126-128.

Tenth section. The training of army airmen. i. Plate, facing p. 144.

Maps for military airmen. [Showing also conventional signs], being a section of a French military "airmap."

7 Hamel, Gustav.

Flying. Some practical experiences. By Gustav Hamel and Charles C. Turner. With illustrations. Lond., [etc., etc.]Longmans, Green & co., 1914.

xii, 341 p. front., pl. 24cm. LC (TL545H2)

Chap. xix. Photography, p. 306-309.

Contains a number of views taken from aerostatic vessels.

8 Hearne, R. P.

Airships in peace and war. Being a second edition of Aerial warfare, with seven new chapters by R. P. Hearne, and introduction by Sir Hiram Maxim, and 73 illustrations. Lond., John Lane; N. Y., John Lane co., 1910. LC (TL545 H5)

xlviii, 324 p. front., illus. 23cm.

Appendix iii. Aerial photography, p. 220-225.

Aviation maps on plates facing p. 234, 242.

9 Hildebrandt, Adolf.

Die luftschiffahrt nach ihrer geschichtlichen und gegenwärtigen entwickelung. 2. verm, und verb. aufl. . . . München und Berlin, R. Oldenbourg, 1910.

vi, 1l., 456 p. col. front., illus. 25cm. LC (TL545 H65)

Kap. 21. Ballonphotographie, p. [396]-402. kap. 22. Photographisches material für ballonzwecke, p. [403]-407. kap. 23. Das lesen von photogrammen, p. [408]-413. kap. 24. Das photographieren mit apparaten, die vermittelst drachen oder brieftauben hochgeführt werden, p. 414-418. Kap. 25. Auswertung von photogrammen, p. 419-421. kap. 26. Brieftauben für ballonzwecke, p. [422]-429.

Frontispiece is a reproduction of a photograph in colors. taken by Prof. Dr. Miethe, at a height of 850 m.

10 Hildebrandt, Adolf.

Airships past and present, together with chapters on use of balloons in connection with meteorology, photography and the carrier pigeons. Trans. by W. H. Story. N. Y., D. Van Nostrand co., 1908.

xvi, 364 p. illus. (incl. ports., maps, facsims.) double plates. 24cm. LC (TL545 H66)

Printed in Great Britain.

Contents.—I. The early history of the art. II. The invention of the air balloon. III. Montgolfieres, Charliers, and Rozieres. IV. The theory of the balloon. V. The development of the dirigible balloon. VI. The history of the dirig-

ible balloon, 1825-1872. VII. Dirigible balloons from 1883-1897. VIII. The same, 1898-1906. IX. Flying machines. X. Kites. XI. Parachutes. XII. The development of military ballooning. XIII. Ballooning in the Franco-Prussian war. XIV. Modern organization of military ballooning in France, Germany, England and Russia. XV. Military ballooning in other countries. XVI. Balloon construction and preparation of the gas. XVII. Instruments. XVIII. Ballooning as a sport. XIX. Scientific ballooning. XX. Balloon photography. XXI. Photographic outfit for balloon work. XXII. The interpretation of photographs. XXVIII. Photography by means of kites and rockets. XXIV. Problems in perspective. XXV. Carrier pigeons for balloons. XXVI. Balloon law. Index.

11 LAUSSEDAT, AIME.

Recherches sur les instruments, les méthodes, et le dessin topographiques, par le colonel A. Laussedat . . . Paris, Gauthier-Villars, 1898-1903.
ES.LC(TA545L38)

2 v. in 3. illus., 32 pl. (22fold.), 6 fold., maps, 9 plans (8 fold.), tables, diagrs. 26 cm.

Contents. t. i. Chap. i. Aperçu historique sur les instruments et les méthodes. Appendice du chapitre i. Instruments et méthodes à l'usage des explorateurs et utilisables en topographie. chap. ii. La topographie dans tous les temps; vues pittoreques et plans géométriques.

. . . .t. ii. 1. chap. iii. Iconométrophotographie. Méthodes. Instruments Métrophotographie. Appendice au chap. iii. Sur le rôle des observatoires militaires pendant le Siège de Paris par les armées allemandes.—Commissaires militaires.—Astronomes et physiciens. Ingénieurs artistes de précision et volontaires des professions diverses.

Planche iii. Première épreuve photographique obtenue en aérostat 1858 par Nadar.

Planche v. Tour d'horizon fait avec la planchette photographique du Dr. Chevallier . . . Tour d'horizon fait avec le périgraphe instantané du colonel Mangin.

Planche vii. Restitution au moyen de deux vues dessinées à la chambre claire.

Planche ix. Chambre claire hémi-périscopique montée sur la planchette.

Planche xi. Chambre noire topographique. t. ii, ptie. 2. chap. iv. Developpement en progrés de la métrophotographie à l'étranger et en France. Methodes et instuments de déssin.—Innovations principales proposées. —Du parti que l'on peut tirer des photographies obtenues dans des circontances exceptionnelles on même de celles que l'on trouve dans le commerce.—Reconnaissances photographiques faites de stations plus ou moins éloignées.—Téléphotographie.—La photographie en ballon.—Photographie par cerf-volant.—La stéréoscopie appliquée à la construction des plans.—Notes, rectificatives.

Planche i. Vues stéréoscopiques obtenues par le Dr. Pulfrich.

Planche ii. Perspectographe de Guido Hauck.

Planche iii. . . . Perspectographe de M. Ch. von Ziegler d'aprés le plan nivelé de M. le capt. Javary.

Planche ix. Vue de Bâle prise en ballon, à 400 m au-dessus du Rhin, par M. Suter.

Planche x. Restitution photogrammétrique d'aprés des vues prises en ballon, par M. S. Finsterwalder.

Planche xi. Vue de Labruguière (Tarn) prise à l'aide d'un cerf-volant, par M. Arthur Batut.

Planche xii. Vue de Berck-sur-Mer prise à l'aide d'un cerf-volant, par M. Wenz.

Planche xvi. Appareil stéréoscopique pour la construction de plans topographiques.

12 LA VAULX, HENRIE, COMTE DE.

Le triomphe de la navagation aérienne; aéroplanes, dirigeables, sphériques. Paris, J. Tallandier, [c1911].

2 p. l., 3-392, [4] p., incl. illus., plates. double pl. 33cm.
ES 23099 LC (TL547L3)

Chap. x. La. photographie en ballon, p. 111-114.

Illustrations.—Fig. [1] Le photo-perspectographe du capitaine Scheimpflug. Fig.[2]. L'appareil à 7 objectifs utilisé par le capitaine Scheimpflug.—Double plate: La méthode directe de levers topographiques par photographies aériennes du capitaine Scheimpflug.—Fig. [3]. Montmartre à vol d'oiseau. Le Sacré-Coeur de Montmartre photographie d'un ballon. Vue prise par M. André Schelcher.—Fig. [4]. La Tour Eiffel à vol d'oiseau. Vue prise par M. A. Schelcher en passant au-dessus de la Tour Eiffel.

Author refers briefly to experiments with kite-photography, on p. 113.

13 LECORNU, J.

Les cerfs-volants. Paris, Monie et cie., 1902.

14 LECORNU, J.

De l'emploi des trains de cerfs-volants montés pour la surveillance des mers et la recherche des sous-marines. Paris, Vuibert, [c1917].

2p. l., p. [5]-24, incl. 17 figs. 24cm. LC (UG607 L4)

Illustrations.—Figs. 1-12; 14 diagrams (fig. 10, fold. pl.); fig. 13 illus., [showing kite "Saconney".] Fig. 15. Lancement d'un cerf-volant à bord d'un navire. Fig. 16. Treuil Saconney pour ascensions en cerfs-volants. Fig. 17. Le départ d'un cerf-volant d'attelage.

15 LECORNU, J.

Sous-marins et cerfs-volants; réponse aux objections. Paris, Vuibert [c1917].

2 p. l., 16 p. 26cm. LC (UG670 L5)

16 LOWE, T. S. C.

Army balloons. (In: Miller, F. T. The photographic history of the civil war, 1911, v. 8, p. 369-382, incl. half-tones).
ES17797 LC(E468.7 M64.v.8)

Sub-title: The balloons with the Army of the Potomac, by T. S. C. Lowe. A personal reminiscence . . .

From "Battles and leaders of the civil war," v. 2, p. 194, 321, 513; v. 3, p. 358

Prof. Lowe ascented in his balloon "Constitution," at Fair Oaks, in May, 1862. He also made a map during one of his flights.

See also: The war of the rebellion: compilation of official records of the Union and Confederate armies. Wash., D. C., ser. i, v. xi, pt. i, p. 456; ser. iii, v. 1, p. 283-284; ser. iii, v. 3, p. 252-319.

The Confederate army tried to construct also an airship soon after the experiments made by Prof. Lowe, in the field, but owing to a lack of supply of silk, they were obliged to use the silk clothes for the purposes, which had been contributed by patriotic women. They were, however, not fortunate to construct a safe balloon, and had to abandon the project after numerous tests and experiments.

17 LUCE, WILLIAM B.

Kites and experiments in aerial photography. Hingham Center, Mass., Author, 1898.

18 MEYER-HEINE, H.

La photographie en ballon et la téléphotographic. Par H. Meyer-Heine, ancien capitaine du génie. Paris, Gauthier-Villars, 1899.

31 p. incl. 19 illus., 20cm.

From: Enseignment supérieur de la photographie (Conférence de la Société française de photographie).

19 MIETHE, ADOLF i. e. CHRISTIAN HEINRICH EMIL ADOLF.

Photographische aufnahmen vom ballon aus. Nach einer serie von vorträgen, die im auftrag des Berliner vereins für luftschiffahrt gehalten worden sind, von geh. reg.-rat Dr. A. Miethe. Mit einer dreifarben-aufnahme vom ballon aus. Halle a.S., W. Knapp, 1909.

3 p. l., 70 p. col. front. 22cm. (Half-title: Encyklopädie der photographie, heft 68). LC (TR819 M6)

Photographs taken from a balloon. Paper prepared from a series of lectures held by author under the auspices of the Berlin aeronautic society. With a three-color view taken from a balloon.

20 MOEDEBECK, HERMANN W. L.

Pocket-book of aeronautics, by Hermann W. L. Moedebeck . . . In collaboration with O. Chanute and others. Author English ed., tr. by W. Mansergh Varley . . . Lond., Whittaker & co., 1907.

xiii, 496 p. incl. illus., tables, diagrs. 17cm. LC (TL551M8) Pat. Off.

Bibliographies accompany some chapters. Chap. vii. Balloonphotography, by Adolph Miethe p. 194-201. chap. viii. Photographic surveying from balloons. By Prof. Dr. W. Kutta . . . p. [202]-216.

21 NEUBRONNER, DR. JULIUS.

Die brieftauben-photographie und ihre bedeutung für die kriegskunst, als doppelsport, für die wissenschaft und im dienste der presse. Nebst einen anhang: Die kritik des auslandes. Dresden, W. Bænsch, 1909.

55 p. incl. illus. 1 plate. 23cm.

Carrier-pigeon photography and its importance in war, as a double sport, and as an aid to science, and in the service of the press. With an appendix: Foreign criticism.

22 OELZE, F. W.

Brieftaubensport und brieftauben-photographie. Unter mitarbeit von W. Dördelmann, J. Neubronner und Fr. Oelze. Leipzig, Grethlein & co., 1910.

178 p. illus. 16cm [?]. (Miniatur-bibliothek für sport und spiel, no. 30-31).

23 PIZZIGHELLI, GIUSEPPE.

Handbuch der photographie für amateure und touristen. Hrsg. von G. Pizzighelli. Halle a. S., W. Knapp, 1891-1903.

3 vols. illus., plates, diagrs. 25 cm. LC. (TR145 .P74.)

Each volume has also special t.-p. Bibliographies at end of sections.

Band 1. Die photographischen apparate. 1891. xii, 685 p. 531. illus.—*bd.* 2. Die photographischen processe. 3. verb. aufl., beareitet von Curt Mischewski. xii, 539 p. 221 illus., 1903.—bd. 3. Die anwendungen der photographie, 1892. x, 496 p. 284. illus.

Band iii. Kapitel vii. Die photogrammetrie. 1. Die principien der photogrammetrie, p. 166-175.—2. Die photogrammetrischen apparate, p. 175-193. A. Die für photogrammetrische arbeiten adaptirte gewöhnliche camera von Le Bon, p. 177-179.—B. Die für photogrammetrische arbeiten adaptirte gewöhnliche camera von F. Schiffner, p. 179-182.—C. Der photogrammetrische apparat von Dr. H. W. Vogel und Dr. Dörgens, p. 182-184.—D. Der photographische theodolit von B. Meydenbauer, p. 184-185.—E. Der photogrammeter von Hafferl und Maurer.—F. Der phototheodolit von Dr. Koppe, p. 185-188.—G. Der photographische theodolit von L. P. Paganini, p. 188-189.—H. Der phototheodolit von V. Pollack, p. 189-191.—I. Der Cylindrograph von Moëssard, p. 191-193.—3. Allgemeiner vorgang bei photogrammetrischen aufnahmen. A. Die photo-

grammetrischen terrainaufnahmen, p. 193-200.—B. Die photogrammetrischen auf nahmen von bauwerken, p. 201-202. 4. Daten über den entwicklungsgang der photogrammetrie und über die bisher angeführten hauptsächlichsten photogrammetrischen arbeiten, p. 202-209. Literatur, 109-211. Kapitel viii. Die aëronautische photographie. 1. Die luftballon-aufnahem. A Wesen der luftballon-photographie und bisher in diesem gebiete vorgenommene versuche, p. 211-213.—B. Die einrichtungen für die ausführung photographischer aufnahmen vom bemannten ballon aus, p. 213-218.—C. Vorschläge Dr. Stolze's und Meydenbauer's zur lösung des problems des photographischen aufnahmen mit fliegendem drachen, p. 226-228.—3. Die photographischen mit der raken-camera, p. 228-229.

24 ROMAIN, C.

Les cerfs-volant-observateurs. Par Commandant Romain. Paris, Nancy, Berger-Levrault, 1912.

27 p. incl. 12 figs. 22cm.

25 TISSANDIER, GASTON.

La photographie en ballon. Avec une épreuve photo-glyptique du cliché obtenu par MM. Gaston Tissandier et Jacques Ducom, à 600 mètres audessus de l'ile Saint Louis, à Paris, et 8 figures dans le texte. Paris Gauthier, Villars, 1886 . VII, 52 [1] p. front, (photog.) 20cm. P.O.

Contents.—i. Premières expériences de M. Nadar, 1858 à 1868.—ii. La photographie en ballon pendant la guerre d'Amerique en 1862.—iii. Expériences de M. Dagron dans l'aérostat captif de M. Henri Giffard, en 1878.—iv.L'Ascension photographique d'Arcueil Cachan (8 juin 1879).—v. Expériences de M. Paul Desmarets en ballon libre en 1880.—vi. Expériences de M. C.—V. Shadbolt en Angleterre en 1883.—vii. L'Appareil panoramique de M. Triboult, pour ballon non monté, en 1884.—viii. Expériences de MM. G. Tissandier et Jacques Ducom, de 19 juin, 1885.—ix. Expériences de M. Pinard, à Nantes, le 14 juillet 1885.—x. Expériences de M. A. Weddel à Paris le 12 octobre, 1885.—xi. Expériences diverses en ballons libres et en ballons captifs non montés. —Conclusion.

Appendice.—Expériences de MM. les capitaines Ch. et P. Renard et Georget en 1885, et de MM. A. et G. Tissandier et Paul Nadar en 1886.

Illustrations.—Front.: Ile Saint-Louis, à Paris.—Fig. 1 Reproduction par l'héliogravure d'un cliché obtenu en ballon libre par M. Shadbolt. Altitude 900 m. au-dessus de Blacklieath.—Fig. 2. Vue intérieure de la cage d'osier contenant les sept appareils photographiques de M. Triboulet.—Fig. 3. Plan de la cage d'osier.—Fig. 4. Coupe longitudinale.—Fig. 5 Coupe horizontale.—Fig. 6. Détails du mécanisme. Coupe d'un objectif.—Fig. 7. Détails de mècanisme vu en plan.—Fig. 8. Reproduction par l'héliogravure du clinché, obtenu à 600 m. d'altitude, par MM. G. Tissandier et Jacques Ducom.—Fig. 9. Ascension de MM. Albert et G. Tissandier et Paul Nadar, ce dernier chargé des opérations photographiques. Vue partielle de Sèvres et de route de Versailles. 1 h. 27 m., le 2 juillet 1886, altitude 800 m.

26 U. S. GENERAL STAFF. WAR COLLEGE DIVISION.

Military aviation. Prepared by the War College division, General Staff corps, as a supplement to the Statement of a proper military policy for the United States . . . Army War College: Washington, Nov., 1915. Wash., Govt. print. off., 1916.

Cover-title, 18 p. 23cm. (War dept. doc. no. 515). ES 23895

Contents.—1. Introduction.—2. General types of aircraft.—3. Functions of aircraft.—4. Organization of aeroplane units.—5. Development of aeronautical personnel.

iii. 12. Photography from aeroplanes, p. 13.

27 WOGLOM, GILBERT TOTTEN.

Parakites. A treatise on the making and flying of tailless kites for scientific purposes and for recreation. New York [etc.], G. P. Putnam's Sons, 1896.

xiv p. 1l., 91 p. front., illus., plates. 26cm. LC (TL820 W84)

Section 24. Large photographic camera in the air,—[on May 25, 1895, . . .], p. 41-43.

28 WOODHOUSE, HENRY.

Textbook of military æronautics, by Henry Woodhouse . . . New York, The Century co., 1918.

6 p. l., 3-298 p. front., illus. (incl. ports., maps) diagrs. 30cm.

ES 25079 LC(UG630 W6)

[Author's name originally: Mario Terenzio Enrico Casalegno]

Contents.—i. The war to be decided in the air.— ii. The warplane for bombing and torpedo attacks.—iii. Dropping bombs from aeroplanes.—iv. Battleplanes and aircraft guns—The dominant factors in maintaining the supremacy of the air . . .v. The fundamental principles of aerial combat.—vi. Directing artillery fire by night and day signaling to and from aircraft.—vii. Kite balloons the eyes of the artillery.—viii. Aero photography.—ix. Reconnaissance and contact patrol work by aeroplane.—x. Night flying.—xi. Radio for aeroplanes.—xii. Military aerostatics.—xiii. Hydrogen for military purposes.—xiv. Training aviators for the United States Army; home and foreign service.—xv. Regulations for uniforms of U. S. aeronautic personnel.—xvi. Aeronautic maps.—xvii. History of the United States Army aeronautics.—xviii. The evolution of military aviation.—xix. Some problems in aeroplane construction.—xx. Methods of measuring aerocraft performances.—xxi. The Sperry automatic pilot.—xxii The case for the large aeroplane.—xxiii. Every military aviator ought to know what his own and the enemy's machine can do and how they look.—Index.

29 WOODHOUSE, HENRY.

Textbook of naval æronautics, by Henry Woodhouse . . . with introduction by Admiral Bradley A. Fiske . . . New York, The Century co., 1917.

7 p. l., 3-288 p. front., illus., diagrs. 31cm. LC (VG 90 W6) WB.

Chap. xx. Aerial photography, p. 121-123, incl. 4 half-tones. chap. xxxi. Photograph taken from kite balloon protecting Venice from attacks by Austrian ships on the Adriatic.

B. Articles from Professional and other Periodicals, Society Papers, Transactions, etc., including Publications of Learned Institutions.

30 ABBOT, HENRY LARCOM.

Early experience with balloons in war. By Brig. Gen. Henry L. Abbot, U. S. army, ret. Prof. M., v. iv, no. 17, Sept.-Oct., 1912, p. 679-682.

ES 20407

31 ABRAHAMS, ADOLPHE.

Some practical ceonsiderations in high-speed photography. Brit. J. P. v. 62, no. 2866. April 9, 1915, p. 240-242; no. 2867. April 16, 1915, p. 254-256 LC. (TR1 B8v.62)

Read before the Roy. Photog. Society. From Photog. Journal, London. March, 1915, p. 107-116.

32 AERIAL PHOTOGRAPHY.

Photo-Min. v. 5, no. 52, July, 1903, p. 145-173. 15 views (8 plates).

LC. (TR1 P67v5)

"Books" [Bibliography]; p. 173.

33 AERIAL RANGE-FINDING WITH ELECTRICAL "EARS".

Sci. Am., v. xciii, no. 18. Oct. 30, 1915, p. 377, front., illus.
ES--LC(T1F5,v.93)

Illustrations.—Front.: Detecting the approach of an enemy aircraft with a French "poste d'écoute,"—p. 377.

Deals with a microphone system for detecting and locating invisible airships and determining ranges.

34 AERONAUT UND PHOTOGRAPHY.

Separat-abdruck aus der Allgemeinen Sportzeitung, Wien. No. 48, Nov. 28, 1886, p. 1-4. Sm.

35 THE AEROPLANE MILITARY SCOUT.

Sci. Am. v. xcix. no. 25. Dec. 19, 1908, p. 450. 600 words. 1 illus.
LC.(T1F5v.99)

Illus. (front.): The aeroplane scout. . . . "The military scout will carry two men; one to operate the machine, and the other to take photographs and make reconnaissance sketches of the country". . . .

36 L'AEROSTATION.

La Vie S., v. 1, 1900, p. 149-150. Sm.

La photographie en ballon, la colombophile à L'Exposition Universelle de 1900.

37 D'AIR, JEAN.

La photographie aéronautique. L'Aéro, 1ere année, no. 25, février, 1900. Sm.

38 D'AIR, JEAN.

Photographie en ballons. Conq. L'Air. 6e. année, no. 4, fév., 1909. p. 5-6. Sm.

The same. 1er année. no. 23, fév., 1909.

39 D'AIR, JEAN.

Revue aéro-photo. L'Aéro, 1ere année, no. 29, 31, mars, avril, 1909. Sm.

40 AN AVIATION GUN-CAMERA OF AMERICAN MANUFACTURE.

Sci. Am., v. cxvi, No. 13. March 31, 1917, p. 329, incl. 1 half-tone.
ES—LC (T1F5, v. 116)

Illustration.—"This aeroplane camera is fitted with Springfield rifle sights and is aimed much in the same manner as a gun."

41 BADEN-POWELL, MAJOR BADEN F. S.

Théorie pratique des cerfs-volants. Résumé d'un mémoire présenté à la Société des Arts de Londres par le capitaine B. F. S. Baden-Powell, le 2e mars 1898. Traduction de M. Desmarest. L'Aéron., xxxie année, No. 10. Oct., 1898, p. 224-233, incl. 6 outline figs. N.Y. Sm.

42 BACON, J. M.

Cloud photography from balloon. By Rev. J. M. Bacon. Aeron, J., v. 4. no. 16. Oct., 1900, p. 146-148.

43 BALLON-PHOTOGRAPHISCHER WETTBEWERB.

Wien, L. Z., iv. jahrg., No. 10. Oct., 1905, p. 200-201. Sm.

Competition for balloon-photographic record of the world.

44 BALLONPHOTOGRAPHIE.

D. Z. L., 14. jahrg., heft 18. Sept. 7, 1910, p. 10-14, incl. Illus., 1 photographic plate. WB.

45 BALLOON-PHOTOGRAPHY.

Aeron. W., v. 1, No. 6, 1903, p. 142. Sm.

46 BANNERMANN-PHILLIPS, H.

Making war photographs from aeroplane. By Major Bannerman-Phillips, English aeronautic correspondent of the Scientific American. (Sci. Am.), v. cxi, no. 17. Oct. 24, 1914, p. 332, incl. 4 half tones.

ES—LC (T1F5, v. 111)

Illustrations.—Views by the Fabbri camera.—Several exposures matched together.—The same. Each exposure automatically records the compass direction and altitude.—The Fabbri automatic camera.—The Fabbri photographic apparatus on an aeroplane.

47 BASSUS, KONRAD, FREIHERR VON.

Einfache art zur bestimmung der lichtstärke eines photographischen objektives. Illus. ær. M., vi. Jhrg., no. 4, Oct., 1902, p. 188.

Sm. WB.

Simple manner to determine the strength of light of a photographic object.

48 BASSUS, KONRAD, FREIHERR VON.

Ergebniss des vom französischen kriegsministerium im jahre 1900 ausgeschriebenen wettbewerbes um photographische objektive mit grosser brennweite für die zwecke der militär-luftschiffahrt. Illus. ær. M., no. 4, Oct., 1902, p. 186-188, incl. 2 figs. Sm.

49 BASSUS, KONRAD, FREIHERR VON.

Photogrammetrischer apparat für die luftschiffahrt bei welchem die photographische camera in einem bestimmten neigungswinkel an einen schulter-anschlag mit libelle sitzt. Illus. œr. M. 4. Jhrg., no. 4, Oct., 1900, p. [83]. 1 diagr. WB.

Treats on a pistol-camera.

50 BASSUS, KONRAD, FREIHERR VON.

The same. ibid., xii. Jhrg., no. 2. April, 1908, p. 79-80. 5 figs. 2 tables. Sm.

51 [BATUT, ARTHUR].

La photographie aérienne par cerf-volant. La Nature, xvie année, 2e sémestre, No. 795. 25 août, 1888, p. 206. 200 words. NM.

At head: "Chronique."

Short note relating to experiments made by A. Batut with photographic apparatus attached to a kite.

52 BATUT, ARTHUR.

Photographic aérienne par cerf-volant. La Nature, xxve année, ler sémestre, no. 1231. 2 janvier, 1897, p. 69-70, incl. 1 illus., 1 outline cut.

NM.

See also Tissandier, Gaston, no. 175.

53 BESANCON, GEORGES.

La photographie aérienne. Aër. Club, No. 7. July, 1916, p. 107-112.

Sm.

A short history of the development of the art of aerial photography, and the achievements up to that date.

La photographie en ballon.—Photo d'une petite ville de la Prusse Rhénane. Prise à 250 mètres d'altitude.—La plaine de Bouilles (Seine-et-Oise) et la ligne de Paris au Havre.—La ville de Middlekerke, dans l'arrondissement d'Ostende (Belgique).—Le revolver photographique allemand.—Biplan à terre photographie, à 300 mètres d'altitude par un autre biplan.—La cathédrale de Reims après des premières bombardements.—Ypres en ruines: La cathédrale Saint-Martin et la maison des drapiers.—Saint-Germain et la viaduc sur la Seine.—Le village et

la fort de Witry—Lès Reims, pris à 2300 mètres d'altitude.—L'église de Labrugière (Tarn) et le pont sur la rivière.—La ville de Casablanca (Maroc), vue photographique prise à 500 mètres de hauteur.—La Plage de Berck, cliché pris à 150 mètres d'altitude.

54 Blanchet, Georges.

La photographie en ballon libre. L'Aéroph., 12e année, no. 3, Septembre, 1904, p. 207-211, incl. 5 illus. Sm.

55 Bois, Th.

Les cerfs-volants et leurs applications militaires. Par Th. Bois, lieutenant du gênie. Rev. du G. M., xixe année, 2e sémestre, t. xxx. Août, 1905, p. [145]-188; Sept., 1905, p.[197]-248; Oct., 1905, p.[323]-360; Nov. 1905, p.[405]-438; Déc., 1905, p.[493]-520, incl. diagrs. ES 6050 LC (UGI R4, v. 30)

Chap. iii. Les applications militaires des cerfs-volants, p. 422.—4. La photographie par cerfs-volants, p. 498-501.—L'appareil photographique, p. 501-503.—La suspension de l'appareil photographique, p. 503-511.—Déclenchment de l'obturateur, p. 511-515.—Restitution des photographies prises par cerfs-volants, p. 515-519.

56 A Bombardment Photographed from an Aeroplane.

Enemy trenches mapped from the air. Illus. L. N., v. 149, pt. i, no. 4041. Sept. 30, 1916, p. 393, illus. LC (AP4, I3, v. 149-i)

Shows French shells bursting over enemy lines.

57 Boulade, Antonin.

Photographie en ballon libre. A. G. I. P., 1904, p. 353-384. Sm.

58 Bourquin, Hans.

Ballonphotographien. Petermanns M., v. 55, part i, heft 1, 1909, p. 17-19. LC (G1, P3, v. 55-i)

59 Bouttieaux, V.

La téléphotographie en ballon. Rev. l'Aér., 7e année, 3e et 4e liv., 1894, p. 99-130, incl. figs. 41-54. Plates 9-11. Sm.

60 Bouttieaux, V.

La téléphotographie. Par Bouttieaux, capitaine du génie. Rev. du G. M., xie année, 2e sémestre, t. xiv. Sept., 1897, p. 103-235, incl. illus., diagrs. ES 3070 LC (UG1 R4, v. 14)

Contents.—Chap. i. Appareils à employer.—1. Appareils à long foyer.—2. Longues-vues photographiques et téléobjectifs. Nature des plaques à employer. Chap. ii Téléphotographie en ballon. Appareils à employer en ballon captif.— . . en ballon libre. Emploi de ballon non montée et de cerfs-volants. Chap. iii. Téléphotographie sur appuis fixes. Chap. iv. Applications de la téléphotographie. 1. Reconnaissances de frontières. 2. Opérations de la guerre de siége. 3. Emploi dans les levers.

61 Brewer, Griffith.

Captive balloon photography. Aeron, J., v. 9, no. 33, 1905, p. 14-15, incl. illus. Sm.

62 Brewer, Griffith.

Photograph by automatic camera from a captive balloon. Am. Aeron., v. 1, no. 1, 1907, p. 21-22, incl. illus. Sm.

63 DIE BRIEFTAUBE IM DIENSTE DER PHOTOGRAPHIE.

Int. Arch. P., band 1, heft 4. Feb., 1909, p. 296.

Short note relating to experiments made by Dr. Neubronner. a druggist at Cronberg, Taunus, Hesse-Nassau, with pigeon-cameras, which are said to have been successful.

64 BROCK, ARTHUR, JR.

Military aeroplane photography. Av., v. 2, No. 8. May 15, 1917, p. 347-348, incl. 2 half-tones. LC (TL501 A8, v.2)

Illustrations.—1. The camp at Columbus, N. M., photographed with a Brock camera.—2. Aviation camera developed by the Folmer and Schwing division of the Eastman Kodak Co.

Daily photographic flghts—Anastigmat lenses—Weight of aeroplane cameras.

65 BRYAN, GEORGE HARTLEY.

Photographs of the paths of aerial gliders. Aeron. J., v. 8, no. 31, 1904, p. 45-51, incl. illus. Sm.

66 CAILLETET'S

Panorama apparat für militärische erkundungen. Illus. ær. M., 4. jahrg., no. 4, Oct., 1900, p. 84. WB.

67 CHAVOUTIER, CHARLES.

La photographie par cerfs-volants. L'Aéron., xxxixe année, no. 10. Oct., 1910, p. 165-177, incl. 4 figs. N.Y. Sm.

Photography by kites.

68 CONCOURS DE CERFS-VOLANTS MONTES.

Prix du commandant Dollfus. Rev. du G. M., xxiiie année, t. xxxviii, 2e sémestre. Août, 1909, p. 180-186.

ES 15187 LC (UG1R4, v. 38)

(Regi par les règlements de la Commission aérienne mixte et de la Fédération aéronautique internationale).

At heading: Science, Physiques, etc.

69 CONCOURS D'OBJECTIFS A LONG FOYER POUR LA TELEPHOTOGRAPHIE EN BALLON.

Génie C., xxxvi, no. 18, (whole No. 925) 3 mars, 1900, p. 288. 400 words. LC (TA2 G3, v. 36)

70 CONCOURS, 3E, PHOTOGRAPHIQUE DE L' (A.-C.D.F.).

Aéron., 6e année, no. 21. Avril, 1907, p. 38.

71 LA CONFERENCE DE M. SOREAU A L'AERO-CLUB DE BELGIQUE.

Conq. L'Air, 6e année, no. 3,4, février, mars, 1909, p. 4; p. 3-4.

Sm.

72 COUSTET, ERNEST.

La photographie aérienne, son emploi dans l'armée. Rev. Scient., 53e année, 1er et 2e sémestre, no. 19, 25. Sept.,-2-9. Oct., 1915, p. 468-469.

LC (Q2R53, v. 53)

73 CROUZET, E.

Etude sur l'emploi des perspectives et de la photographie dans l'art des levers du terrain. Par E. Crouzet, Colonel du génie en retraite. Rev. du G. M. 15e année, t. xxii. 2e sémestre. Déc., 1901, p. [529]-556; 16e année, t. xxiii, ler sémestre. Janvier, 1902, p. [63]-94, incl. illus. diagrs. LC (UG1 R4.) ES.

Chambre claire du colonel Goulier, fig. 4, p. 540.—Télémétrographe. Téléiconographe, p. 541. Appareil Laussedat, p. 543. Travaux du capitaine Javary, p. 547. Perspective cylindriques—rayonnantes, p. 551. Planchette Chevalier, p. 522, and figs. 5, 6, p. 553-554. Périgraphe instanté Mangin, p. [63], and fig. 7, p. 64. Orographe Schrader, p. 66, and fig. 8, p. 67. Photographies en ballon, en cerf-volant, etc., p. 80-82. Travaux exécutés par la métrophotographie, p. 82-88. Lever du Mont-Blanc, par MM. Joseph et Henri Vallot, p. 88-94.

74 CROUZET, E.

Photographies en ballon, en cerf-volants, etc. Par E. Crouzet, colonel du génie en retraite. Rev. du G. M., xvie année, 1er sémestre, t. xxiii, janvier, 1902, p. 80-94. ES 6632 LC (UG1, R4, v. 23)

75 DEBURAUX, EDOUARD.

See DEX, LEO.

76 DEGOUL, MARIUS.

La photographie terrestre et aérienne à longue distance. L'Aéroph., 14e année, no. 8. Août, 1906, p. 166-167, incl. 2 figs. Sm.

77 DESMARETS, PAUL.

La photographie en ballon libre. Aéron., 13e année, no. 10, octobre, 1880, p. 234-238. Sm.

78 DEX, LEO [PSEUD. OF EDOUARD DEBURAUX

La photographie en ballon. Rev. Scient. xxixe année, 2e sémestre, t.1, 2 julliet au 31 déc., 1892, p. 296-302, incl. 2 diagrs

LC(Q2 R53,v.50-2)

Contents.—Des clichés.—i. Influence de l'éclairage et de la pureté de l'air.—ii. Influence de mouvement de l'aérostat.—iii. Mode d'opérer.—Aërostat naviguant au guiderope.—Ballon captif.—Ballons non montés.—Des épreuves. 1. Photographies verticales. Relief Uniformité de la teinte. 2. Photographies de lointains. Services que peut rendre la photographie en ballon. 1. Ballon libre. 2. Ballon captif. 3. Ballon non montés.

Note.—Léo Dex is pseudonym for Edouard Deburaux, Commandant d'aérostiers, born at Batna, Algeria, in 1864, died 1904.

79 DRACHEN ALS MILITAERISCHE BEOBACHTUNGSMITTEL.

D.Off., xiv. Jahrg., no. 4. 27. Januar, 1910, p. 66-67. Sm.

Signed: "n."

Heading: Aus dem gebiete der luftschiffahrt.

A brief review of experiments made by Saconney, Wise, Baden-Powell, etc., and operations and material explained.

80 DUCOM, J

Ballonphotographie durch J. Ducom und G. Tissandier. Photog. Woch., 1885. Sm.

81 EDDY, WILLIAM A.

Photographing from kites. Cent. M., v. liv, new series, v. xxxii, no. 1. May, 1897, p. 86-91, incl. 2 half-tones. LC(AN,v34,n.s.)

Sub-title: Including accounts of the first photographing from kites and of the first telephoning and telegraphing through a line held by kites.

Illustrations.—Telegraphing with the aid of kite.—Eddy's aërial camera.

82 EDDY'S KITE PHOTOGRAPHS.

Aeron. W., v. i, no. 5, 1902, p. 115. LC(TL501 A4.v.1)

83 FAULKNER, G. L.

Britain's bid for the control of the air. The airman's duties at the front and how he executes them. By Lieut. G. L. Faulkner, of the

British Royal Flying Corps. Sci. Am., v. cxvi, no. 22. June 2, 1917, p. 544,545, incl. 5 illus. ES__LC(T1F5,v.116)

Illustrations.—1. A typical battleplane of the Allied Air Fleet. This machine carries three men and is armed with a rapid-fire cannon of small caliber. 2. A single-seater high speed British scout machine equipped with a rotary engine. 3, 4, 5. Entente aircraft over the sea, "No man's land," and in back of the lines engaged in naval and military scouting, and in night-flying practice.

"Photographs that pave the way for an offensive," p. 544.

84 FONVILLE, WILFRID DE.

Aerophotographie. Wien. L. Z., vii. Jahrg., no. 5. Mai, 1908, p. 99-101, incl. 4 illus. Sm.

85 FONVILLE, WILFRID DE.

La photographie en ballon et en cerf-volant. Cosmos, t. lvii, no. 12, 1908, p. 93-98. N.Y. Sm.

86 FONVILLE, WILFRED DE.

La photographie en ballon. Spect. M., 4e série, t. x, no. 29. Août, 1880, p. [253]-258. LC(U2S7,v.10)

87 [FOURNIER, LUCIEN]

Les ballons cerfs-volants Lucien Fournier. La Nature, v. xliii, 1er sémestre, no. 2178. 26 juin, 1915, p. 411-413, incl. 3 half-tones, 3 sections. LC(Q2N2,v.43-1)

Illustrations.—1. Le ballon cerf-volant pendant une observation.—2. Système de suspension d'un ballon captif (modèle Yon).—3. Sous l'action du vent le ballon asphérique descend; la nacelle tourne souvent dans un sens et le ballon dans l'autre. On arrive difficilement à maintenir l'officier observateur dans une position favorable à ses observations.—4. Figure schématique montrant les organes du ballon cerf-volant.—Le manoeuvre à terre du ballon.—6. Atterissage d'un ballon cerf-volant.

88 FRENCH CAMERAS WHICH SNAP THE ENEMY'S WORKS AGAINST HIS will. Sci. Am., v. cxviii, no. 10. March 9, 1918, p. 213. 300 words, incl. 1 illus. ES__ LC(T1F5,v.118)

Illustration.—Some of the cameras employed by the French airmen operating over the Aisne sector.

89 FUNCKE, A., VON.

Ballonphotographie. D. Z. L., xiv. jahrg., no. 18, 1910, p. 10-11, incl. 5 half-tones. LC(TL503D4v.14)

Illustrations show views taken from a balloon.

90 GAULT, A. C.

Photography from a kite. Sci. Am., v.cviii, no. 23. June 7, 1913, p. 514, incl. illus. ES__ LC(T1F5,v.108)

Illustrations.—1. The kite reel and the camera attached to the wire.—2. View of Delmar, Iowa, from an elevation of 700 ft.—3. Kite and camera en route to the field.—The preferred form of camera bracket.—5. Looking down on a quarry from an altitude of 300 ft.

91 GERVAIS-COURTELLEMONT, M.

Military aerial photography. Flying, v. vii, no. 1. Feb., 1918, p. 28-34. 1,370 words, incl. 10 half-tones. ES__ LC(TL501 F7,v.7)

Illustrations.—Aeroplane photography that shows minutest details of a factory chimney being repaired. Camera mounted on a British B. E. biplane.—French photography twin motored biplane.—Lines of trenches on the western front photo-

graphed from an aeroplane. Soldiers are shown walking along trenches.—British Naval Flying Corps students being instructed in the handling of an aeroplane camera.—Two aeroplane British Royal Flying Corps cameras being returned after a flight.—Seven aeroplane bombs photographed soon after released by the French aviator that released them on a German plant.—Four types of aeroplane cameras used by the French air service.—A motion-picture camera being mounted on an Italian Macchi flying boat. . . . photo shows buildings on fire after bombs were dropped.

92 GOERZ PHOTO-STEREO-BINOCLE.

Illus. aer. M., no. 4. Oct., 1900, p. 130-131, incl. illus. Sm.

Signed: Rieckeheer.

93 GOLDBERG.

Das Scheimpflug'sche system einer kartographierung aus der luft. Prom., v. xxv, no. 10, (whole no. 1,258) Dec. 6, 1913, p. 145-149, incl. 9 illus. E. N.Y. Sm.

Fig. 147. Th. Scheimpfugs achttheilige aero-kamera während der belichtung. Fig. 148. Aero-kamera für landvermessungen. Ansicht von unten. Fig. 149. Photographische universal-transformation, Scheimpflug-Kammerer. Fig. 150. Ballonaufnahme aus ca. 700 m. höhe mit rund 45 degrees neigung. Transformation in die horizontalebene. Die Rotunda in Wien. Fig. 151. Die Rotunda in Wien. Korrespondierender ausschnitt aus dem stadtplan. Fig. 152. Original-aufnahme mit dem panorama-apparat. Original-aufnahme zum gesamt-panorama umphotographiert. Fig. 153. Korrespondierender karten ausschnitt zu fig. 152.

94 HAGEN, FRIEDRICH VON.

Das photographieren vom ballon aus. Mit einem lichtdruckbilde. Zeit. L., vi. jahrg., heft 1, 1887, p. 2-6, incl. 1 illus. 1 plate LC(TL503 Z48,v.6)

95 HARE, JAMES H.

Aerial photography—a new art. Flying, v. iii, no. 4. April, 1914, p. 101-105; 112-113, incl. 9 half-tones. LC(TL501F7,v.3)

"Photographs taken from aircraft published in past numbers of "Flying," p. 112-113.

96 HINTERSTOISSER, FRANZ.

Uber Ballonphotographien. Zeit. L., xiii. heft 6, 1894, p. 160-163.

97 HONORE, F.

Les cerfs-volants militaires. Illus., lxviiie année, t. cxxxv, no. 3,492. 29 janvier, 1910, p. 84, incl. illus. LC(AP20,13,v.135)

Illustrations.—Une accession avec les cerfs-volants du capitaine Saconney. Les câbles et les bambous reliant les deux éléments de chaque cerf-volant ne sont pas venus sur le cliché, mais on aperçoit le chariot supportant la nacelle.

98 HOUARD, GEORGES.

La cartographie aérienne. Par Georges Houard, Secrétaire général de la Ligne française du cerf-volant. In: Science V. t. xii, no. 33, juin-juillet, 1917, p. [35]-50, incl. port., maps, illus., diagr.

AW. Monthly List, Sept., 1917, item 3.

Illustrations: Portrait, Le Colonel Laussedat.—View: La Dordogne au Bec d'Ambés et les trois iles de Bourg-Gironde. Photographie obtenu au moyen de cerfs-volants par M. Marc Pujo . . . prise à faible hauteur 450 m. environ p. 38. Map: La région du Bec d'Ambés représentée par une ordinaire, p. 39. —Diagram: Principe du perspectographe, p. 40. Illustration: "Ces clichés ont été pris à plus de 2500 m. de hauteur," p. 40.—"Les huit vues redressées au perspectographe et assémblées pour former une carte géographique, p. 41.—Map:

Carte ordinaire de la région photographiée par le "Scheimpflug."—L'Appareil Scheimpflug à chambres multiples, p. 42.—Appareil Scheimpflug à huit chambres fixé à la nacelle d'un ballon libre, p. 43.—Le perspectographe pour le redressement photographique des clichés, p. 44.—Appareil Douchet pour la photographie à bord des aéroplanes, p. 45.—Vue schématique de l'appareil Douchet, p. 46.—Montage de l'appareil photographique Douchet dans le fuselage d'un avion, p. 47.—Fragment d'un film obtenu par l'appareil Douchet, après assemblage des photographiques successives, p. 48.—Intéressante photo aérienne prise à une très faible hauteur, p. 49.

99 HOW IT WORKS: I. AERIAL PHOTOGRAPHY EMPLOYED IN WAR.

Illus. W. N., v. 7, part 73. Dec. 29, 1915, p. 18-19, incl. illus., diagrs.
AW. Monthly List, Feb., 1916, item no. 491.

Fig. 5. Diagram of the mechanics of the Fabbri photographic apparatus. Fig. 1. Aviator seen making a continuous photographic record. . . . Fig. 2. Fabbri apparatus fitted to a fast scout. Fig. 3. Conjoined prints forming a continuous record. Fig. 4. The Maül camera parachuting to the earth after the photograph has been taken.

100 HOW THE AERIAL PHOTOGRAPHER SNAPS HIS VIEWS.

Sci. Am., v. cxviii, no. 4. Jan. 26, 1918, p. 91. 125 words, incl. front., 1 half-tone. ES__ LC(T1F5,v.118)

Frontispiece: Taking photographic notes on a reconnaissance flight.—[Fig.1]. One exposure after another can be made with this airplane magazine camera.

101 INTERNATIONALER PHOTOGRAPHISCHER WETTBEWERB.

Wien. L. Z., v. Jahrg., no. 4. April, 1906, p. 82. Sm.

102 INTORNO ALLA TELEFOTOGRAFIA AEROSTATICA.

Soc. Aer. Ital., anno iii, no. 5-6. Maggio-gui., 1906, p. 175. E. N.Y.

103 JANSSEN, J.

Note sur le principe d'un nouveau revolver photographique. L'Aéron., xve année; no. 7. Juillet, 1882, p. 143-146. NY. Sm.

104 [JENNINGS, W. NICHOLSON]

Aerial photography. Photo. T., v. xxvii, no. 5. Nov., 1895, p. [257]-262, incl. 7 half-tones. ES 3007 LC(TR1P8,v.27)

Illustrations.—[Balloon in flight], By Franz Hinterstoisser.—[View] taken from a balloon at a height of 800 m., by Lieut. L. David.—[View] Balloon view of Girard College, Philadelphia.—M. Batut's kite camera.—[View] Jamaica, L. I., from an elevation of 1000 ft.—[View] taken from a captive balloon at a height of 600 m. by Franz Hinterstoisser.

105 JENNINGS, W. NICHOLSON.

Balloon photography. Fly, v. i, no. 8. June, 1909, p. 4-5, incl. 4 illus.
LC(TL501 F6,v.1)

Illustrations.—Clouds over the Alps.—Pyramids of Cheops, Chepherm and Mencheres.—Photograph of Vienna.—Shadow of a balloon shown in the clouds, car surrounded by a rainbow. Pictures taken by Spelterni and Hinterstoisser.

106 KABISCH, E.

Aerial reconnaissance during sieges. Sci. Am. S., v. lxxviii, no. 2,017. Aug. 29, 1914, p. 134. ES__ LC(T1F52,v.78)

Translated from "Militär-wochenblatt."

Sub-title: Its important influence on artillery attack and defense.

107 KAMMERER, G.

Geographical charts prepared by special photography. Sci. Am. S., v. lxxv, no. 1,949. May 10, 1913, p. 300-301, incl. illus.
Es__ LC(T1F52,v.75)

Illustrations.—Painting distorted by oblique perspective.—Top view of the aero camera.—Painting corrected for distortion.—Orthogonal map prepared from aero camera views.—Eight-view aero camera ready for an exposure.—The perspectograph, which corrects photographs for distortion.—The sectional maps of next view reconstructed, into a single view by the perspectograph.—Eight separate sectional views taken simultaneously by the aero camera.

108 KASSNER, C.

Ueber Wolkenphotographie, insbesondere bei ballonfahrten. Zeit. L., xi. Jahrg. heft 2, 1892, p. 57-59. LC(TL503Z48,v.11)

109 KASSNER, C.

Zur ballanphotographie. Von Dr. C. Kassner. Zeit. L., xiv. Jahrg., heft 8, 9, 10, 1895. LC(TL503Z48,v.14)

This is a discussion of an article by W. N. Jennings [which see], in the American annual of photography and Photographic times for 1895.

110 KITE APPARATUS AT RUSSIAN MANEUVERS.

Aeron. J., v. iii, no. 9. Jan., 1899, p. 19. LC(TL501 A35,v.3)

Short note, from "Broad Arrow."

Kites were used by all arms in Russian maneuvers, 1898.

111 KITES FOR WAR PURPOSES.

Army N. G., v. xxxviii, no. 1943. April 17, 1897, p. 350. AW. LC(U1 A65,v.38)

At head of article: "Communicated."

112 LEHRREICHE AERONAUTISCHE PHOTOGRAPHIEN.

Illus. aer. M., ix. Jahrg., heft 4. April, 1905, p. 122-123; heft 5. Mai, 1905, p. 156-158, incl. 3 figs. LC(TL503 D4,v.9) Sm.

See also Moedebeck, Herm. W. L.

113 LELARGE.

Méthodes téléphotographiques. Par Lelarge, Lieut. du Génie. Rev. du G. M., xxe année, 2e sémestre, t. xxxii. Sept., 1906, p. [193]-230; octobre, 1906, p. [293]-324, incl. diagrs. ES 8389 LC(UG1R4,v.32)

Chap. v. Application des méthodes précédentes au ballon libre, p. 301-311.—Chap. vi. a. Abaque de la formule en téléphotographie, p. 311-316.

114 LOCKYER, WILLIAM J. S.

Cloud photographs from a balloon. Nature, L., v. lxxx, no. 2063. May 13, 1909, p. 310-311, incl. figs. 1-2. LC(Q1N2, v.80)

115 LUFTSCHIFFAHRT UND BALLONPHOTOGRAPHIE.

Wien. L. Z., iv. Jahrg., no. 3, März, 1905, p. 58-59. Sm.

116 MANDL, JULIUS.

Verwertung von photographischen aufnahmen aus dem luftballon. Von Julius Mandl, k. und k. Hauptmann des geniestabes, Lehrer am höheren genie-curse. Mittheil. G. A. G. xxix. jhrg., heft 3, 1898, p. 165-194. plates 7, 8, (part fold). ES. LC. (U3 M7 v. 29, 1898.)

Contents.—Ermittelung von standpunkt und orientierung des apparates bei unbekannter objectivbrennweite und unbekannter lage der hauptachsen. (Problem der fünf punkte), p. 167. [Dasselbe], bei bekannter objectiv-brennweite und bekannter lage der hauptachsen. p. 179. Anhang, p. 181. Ebene gebilde, projectivische verwandschaft. Die involution, p. 187. Deck elemente, p. 191. Erzeugniss zweier projectivischer strahlenbüschel, p. 191. Kegelschnitte-büschel, p. 193.

117 MARESCHAL, G.

Photographie aérienne avec un appareil commandé à distance. La Nature, t. xxxvii, ptie. i, no. 1862. 30 janvier, 1909, p. 131-134, incl. 6 figs. LC (Q2N2, v. 37-1)

Illustrations.—Fig. 1. La suspension de l'appareil.—Fig. 2. Mécanisme de l'appareil.—Fig. 3. Appareil photographique Roger Aubry.—Fig. 4. Le treuil du cable et la dynamo.—Fig. 5. L'Installation de l'opérateur pour la prise des clichés.—Fig. 6. Viaduc de Marly-le-Roy. Photographie obtenue avec l'appareil.

118 MEYER-HEINE, H.

La photographie en ballon. A. C. A. M., 3e série, t. i.

119 THE MILITARY CARRIER-PIGEON PHOTOGRAPHER.

Sci. Am., v. cxi, no. 15. Oct. 10, 1914, p. 297, incl. 4 half-tones. ES—LC (T1F5, v. 111)

Sub-title: The homing pigeon in the army.

Illustrations.—Portable. collapsible cote for military use.—Carrier pigeon equipped with a two-lens camera.—Magnified picture taken by a carrier pigeon.—A two and one half-ounce apparatus for taking eight pictures.

120 THE MILITARY ROCKET CAMERA

Sci. Am., v. cxii, no. 6. Feb. 6, 1915, p. 125, incl. 5 half-tones. ES—LC (T1 F5, v. 112)

Illustrations.—1. The rocket ready for firing.—2. The rocket camera and its accessories. The whole apparatus an be carried on a small hand-cart and easily taken to the front.—3. At the instant of discharge.—4. View of Laussnitz, Saxony, obtained by a rocket camera at an elevation of 2,000 ft.—5. The descent.

121 MILLET, J. B.

Scientific kite-flying. Cent. M., v. liv, new series, v. xxxii. May, 1897, p.[66]-77, incl. 17 illus. LC (AN v. 32, n. s.)

Sub-title: With special reference to the Blue Hill experiments.

122 MILLWARD, RUSSELL HASTINGS.

Exploring and mapping jungle lands by aeroplane. Flying, v. vi, no. 12. Jan., 1918, p. 1044-1047, incl. port., 4 half-tones. ES—LC (TL501 F7, v. 6)

123 MITTAG, E.

Aeronautische photographie. Ballanphotographie. Illus. ær. M., x. Jahrg., heft 5. Mai, 1905, p. 163-169, incl. 5 half-tones. LC(TL503 D4,v. 10)WB.

Illustrations.—Fig. 1, 2. Aufnahme, Zürich vom ballon aus, ca. 320 m. höhe und ca. 1000 m über der stadt mit Goerz-Anschütz-Klapp camera von Kapitain Spelerini.—Fig. 3. Die Mischabelhörner ca. 4400 m. höhe über meer.—Fig. 4. Jerichow, bezirk Magdeburg. Aufnahme von Dr. Bröckelmann, höhe 250 m. über stadt.—Fig. 5. Glatte landung.

124 MOEDEBECK, HERMANN W. L.

Lehrreiche aeronautische photographien. Illus. ær. M., ix. Jahrg., heft 9. Sept., 1905, p. 289-291, incl. 2 figs. LC (TL503 D4, v. 9) Sm.

125 MONNIOT, W.

La photographie en ballon. L' Aéroph., ive année, no. 5. Mai, 1896, p. 93-94. Sm.

126 MOUSSARD, E.

La téléphotographie en dirigeable et en aéroplane; ses applications à la défense nationale. (Séance générale du 19 mai 1911). Soc. F. Phot., lviie année, 3e série, t. ii. Juillet, 1911, p. 234-242. LC (TR1 S6, 3 ser., v. 2)

127 MUELLENHOFF, ÆARL.
Die photographie im papierdrachen. Photog. M., 1890.

128 NEUBRONNER, DR. JULIUS.
Die brieftaube als photograph. Umschau, xii. jahrg., no. 41, 1908.

129 NEUREUTHER, K.
Ballon-photographie. Illus. ær. M., vii. Jahrg., heft 9. Sept., 1903, p. 312-313, incl. illus. LC (TL503 D4, v. 7) Sm.

130 NEUREUTHER, K.
Ein 2me Concours international de photographie. Illus. ær. M., x. Jahrg., heft 6. Juni, 1906, p. 212.
LC (TL503 D4, v. 10) Sm.

131 NOCH EINMAL DIE BALLONPHOTOGRAPHIE.
Prom., ii. Jahrg., no. 64, 1891, p. 184-185, incl. 1 illus.
E. N.Y. Sm.

132 PERROTIN, H.
Appareils photographiques des Zeppelins et des Aviatiks. La Nature, v. xliii, ptie. 1, no. 2168. 17 avril, 1915, p. 262.
LC (Q2N2, v. 43-1)

Illustrations.—Fig. 1, 2. Appareil photographique du Zeppelin.—Fig. 3. Appareil photographique **de l'aviation allemande** (9x12).

. . . "Les escadrilles des deux corps expéditionnaires d'Orient (capitaines Vitrat et Cesari) ont même déjà munies de ces appareils métalliques 13x18 nouveau modèle.

133 PEZET.
De la restitution du plan au moyen de la téléphotographie en ballon. Par Pezet, capitaine du génie. Rev. du G. M. 20e année, t. xxxi. 1er sémestre. Mai, 1916, p. [377]-420; juin, 1906, p. [473]-506, incl. illus. diagrs. plans. ES. LC. (UG1 R4, v. 31.)

Contents.—Historique, p. 378-379.—Conditions de la reconnaissance par la téléphotographie en ballon, p. 378-381. Chap. i. Restitution au moyen de deux épreuves photographiques, p. 381-387.—Relèvement de la position du centre optique, p. 387-395.—Détermination de la projection du centre optique sur la plaque, p. 395-400.—Opérations graphiques de la restitution, p. 400-405. Chap. ii. Restitution au moyen d'une seule photographie, p. 405-420. Opérations graphiques, p. 476. Détermination de la position du centre optique par la photographie, p. 476-484. Altigraphe, fig. 28, p. 484. Des. photographs comportant plus d'un repère, p. 485-497. La téléphotographie à bord des dirigeables, p. 497-506.

133a PHELIP, GASTON.
La photographie aérienne et ses applications militaires. La Nature, v. xxxvii, ptie, 1, no. 1877. 15 mai, 1909, p. 376-380, incl. 9 figs.
LC (Q2N2, v. 37-1)

Illustrations.—Fig. 1 [Sketch map]; (below half-tone): Spécimen de levé rapide effectué en rade de Casablanca au moyen d'une seule photographie.—Fig. 2. Photographie de Safi . . .—Fig. 3. Vus de Morgador prise à 200 mètre d'altitude et à deux milles de la côte, par cerfs-volant élevés au "mouillage".—Fig. 4. Appareil remorqué par un "Cody" le long du cable tenda par deux cerfs-volants "Lenoir".—Fig. 5. Départ de l'appareil remorqué par un cerf-volant "Lenoir".—Fig. 6. Experiences à bord du "Desaix" en rade de Morgador. Retour de l'appareil à bord.—Fig. 7. Détail du gréement d'un train type Saconney et du dispositif de remorquage de l'appareil photographique.—Fig. 8. Graphique sur papier calque porté sur la carte pour déterminer la position de la station S.—Fig. 9. Détermination de l'horizon.

134 PHOTOGRAPHIC APPARATUS EMPLOYED BY GERMAN AIRMEN.

Sci. Am., v. cxiii, no. 26. Dec. 25, 1915, p. 562, 564. 95 words, incl. 1 half-tone. ES—LC (T1 F5, v. 113)

Illustration: Two types of cameras used by German airmen.

135 PHOTOGRAPHIC MAPS.

Sci. Am. S., v. lxxx, no. 2073. Sept. 25, 1915, p. 200-201, incl. illus., diagrs. ES—LC (T1 F52, v. 80)

Illustrations.—Fig. 1. How objects at the side of the field are masked by other objects.—Fig. 2. Scheimpflug multiple camera (side and bottom views).—Fig. 3. Multiple camera attached to the balloon car.—Fig. 4. Overlapping fields of central and lateral cameras.—Fig. 5. The rectifying camera.—Fig 6. A correct photograph distorted by the rectifying camera.—Fig. 7. An oblique photograph rectified.—Fig. 8. Photograph of a cemetery viewed obliquely from a balloon.—Fig. 9. The oblique view (Fig. 8), corrected by use of the rectifying camera.—Fig. 10. Official map of district shown in figs. 8 and 9.—Fig. 11. A group of negatives made simultaneously with the multiple camera.—Fig. 12. Oblique views rectified and combined with the central figure. —Fig. 13. One of the inclined views rectified.—Fig. 14. Map of the region photographed in figs. 11 and 12.—Fig. 15. Disproportion between opposite flanks of a mountain photographed obliquely.

Sub-title: Map making by direct photography. The Scheimpflug multiple camera. Photographic maps. Methods of producing correct charts with the camera.

This is an abstract of an article by city surveyor Kappel in "Die Umschau," on the methods of producing correct charts with the aid of the "Scheimpflug" camera.

136 PHOTOGRAPHIC SCOUTING AT NIGHT.

Sci. Am., v. cv, no. 19, Nov. 4, 1911, p. 404, incl. 1 half-tone. ES—LC (T1 F52, v. 105)

Sub-title: An artist's contribution to an aeronautic problem.

Illustration.—Making night photographs from an aeroplane.

137 PHOTOGRAPHIE AERONAUTIQUE.

Conq. L'Air, 5e année, no. 1. Janvier, 1908, p. 3, incl. 1 illus. Sm.

138 PHOTOGRAPHIE AUS DER VOGELPERSPEKTIVE.

Prom., band 1, no. 40, 1890, p. 629-631, incl. 2 illus. E. N.Y.

Signed: S.

Illustrations.—Ausrüstung des photographischen fesselballons.—Panoramische aufnahme vom photographischen drachen aus.

Photography from the bird's-eye perspective.

Illustrations.—Equipment of the captive ballon.—Panoramic views taken from the photographic kite.

139 LA PHOTOGRAPHIE EN BALLON.

L'Aéroph., ixe année, no. 9. Sept., 1901, p. 231-232; no. 10. Oct., 1901, p. 252. E. N.Y. Sm.

140 LA PHOTOGRAPHIE EN BALLON.

A. Scient. I., xxxe année, 1886, p. 179-180. 340 words. LC (Q9, A3, v. 30)

Reviews the labor and results of Paul Nadar and the Tissandier brothers, as well as of the captains P. Renard and Georget.

141 PHOTOGRAPHING FROM AN AEROPLANE.

Sci. Am. S., v. lxix, no. 1783. March 5, 1910, p. 153, incl. 4 half-tones. ES—LC (T1F52, v. 69)

Sub-title: Pictures taken from Latham's "Antoinette".

Abstract of an article in "L'Illustration."

Illustration.—The aeroplane sheds at Lonvercy as viewed from an "Antoinette" monoplane.—Side view from monoplane showing another "Antoinette" monoplane in front of the sheds.—View looking forward from the "Antoinette" monoplane in flight.—Side view along rear edge of wing of monoplane.

142 PHOTOGRAPHING FROM A SKYROCKET.

Sci. Am., v. cviii, no. 6. Feb. 8, 1913, p. 140, incl. illus.

ES—LC (T1F5, v. 108)

Illustrations.—Königsbrück, photographed from a rocket.—The military rocket-camera knocked down for transportation.—The rocket head, the stick with wooden feathers and the frame.—Rocket photograph of Steuz village under snow. Laussnitz village photographed from a rocket.—The camera-carrying rocket in its frame ready for firing.—A snapshot of the rocket at the moment of firing.—The parachute bringing apparatus to earth.

143 PHOTOGRAPHISCHE AUFNAHMEN AUS DER "HANSA."

D. Luftf. Z. B., xvii. Jahrg., no. 12. Juni 11, 1913, p. 285, incl. 1 half-tone. E. N.Y. WB.

Illustration.—Aufstellung der truppen Unter den Linden, beim einzug des königs von England. (Forming of troops "Unter den Linden," Berlin, during the entry of the king of England.

144 PHOTOGRAPHISCHER WETTBEWERB DES "AERONAUTIQUE CLUB DE FRANCE."

(Premier concours international de photographie aérienne). Wien. L. Z., iv. Jahrg., no. 4. April, 1905, p. 76-77. Sm.

145 PHOTOGRAPHISCHER WETTBEWERB BALSAN.

Wien. L. Z., v. Jahrg., no. 6. Juni, 1906, p. 115-116; vi. Jahrg., no. 5. Mai, 1907, p. 93-94; vii. Jahrg., no. 7. Juli, 1908, p. 149-150. Sm.

Relates to a photographic competition, called "Balsan."

146 PHOTOGRAPHY FROM A BALLOON.

Aeron. W., v. i, no. 1, 1902, p. 14-15; no. 3, 1903, p. 58-59.

N.Y. LC (TL501 A4, v. 1). Sm.

147 PILLET, F. J.

Note concernant la construction d'un cerf-volant pour recherches scientifiques, explorations atmosphériques et relevés photographiques. L'Aéron., xxxive année, no. 6. Juin, 1901, p. 131-140. 1 plate N.Y. Sm.

148 A PISTOL-CAMERA FOR GERMAN AIRMEN.

Found in an aviatik. Illus. L. N., v. 148, 2d pt., no. 4020. May 6, 1916, p. 599. 160 words, incl. 3 illus.

LC (AP4, I3, v. 148-2)

AW. Monthly List, July, 1916, item 318.

Illustrations.—The German pistol camera for airmen in use during a flight.—An observer taking photographs by pressing the trigger.—Pistol-camera right side.—The same, left side.

149 PISTOLET TELE-PHOTOGRAPHIQUE DES AVIATEURS ALLEMANDS.

Illus., v. 147, 2e ptie. 22 avril, 1916, 126 words, incl. 2 half-tones.

AW. LC (AP20 13 v. 147-2)

150 PREMIER CONCOURS INTERNATIONALE DE PHOTOGRAPHIE AERIENNE.

Aéron., ive année, no. 13. Avril, 1905, p. 39-40; ve année, no. 16. Janvier, 1906, p. 95-97. Sm.

151 RAMEAU, LOUIS.

La photographie en ballon. L'Aéron., xxe année, no. 4. Avril, 1887, p. 63-64. N.Y. Sm.

152 RECONNAISSANCES PHOTOGRAPHIQUES MILITAIRE A TERRE EN MER ET en ballon. Conq. L'Air, ive année, no. 17. Dec., 1907, p. 3-4. Sm.

From L'Aéro-revue. Bulletin mensuel de l'Aéro-club du Rhône et du Sud-Est.

153 RESULTATS DE NOTRE PREMIER CONCOURS DE PHOTOGRAPHIES.

Conq. L'Air, ive année, no. 16. Août, 1907, p. 3. Sm.

154 RUCKSTUHL, E.

La photographie aérienne par pigeon-voyageurs. L'Aéroph., xviie année, no. 2. Janvier, 1909, p. 47, incl. 2 illus. E. NY. Sm.

155 SACONNEY, JACQUES THEODORE.

Cerfs-volants militaires. Par J. Th. Saconney, Capitaine du génie. Rev. du G. M., xxiiie année, t. xxxvi, 1er sémestre. Février, 1909, p. [151]-178; mars, 1909, p. [235]-268; t. xxxviii, 2e sémestre. Août, 1909, p.[125]-154, incl. illus., diagrs. ES15185;15187 LC(UG1R4,v.36,38)

Le cerf-volant observatoire, p. [151]-178.—L'Observatoire aérienne, p. [235]-268; v. 38, p. [125]-154.

156 SACONNEY, JACQUES THEODORE.

Reconnaissances photographiques militaires à terre, en mer et en ballon. Par J. Th. Saconney, . . . Rev. du G. M. xxie année, t. xxxiii. 1er sémestre. Février, 1907, p. [143]-160; avril, 1907, p. [329]-362; mai, 1907, p.[423]-468; juin, 1907, p. [543]-573; (à suivre), incl. diagrs, illus. LC. (UG1R4, v. 33.) ES.

Reconnaissances par téléphotographie, p. 149.—Appareil téléphotographiques, p. 151; 333; 427; 547.—Téléphote de MM. Vautier et Dufour, fig. 9, p. 152.—Cylindrographe, p. 155.—Périgraphe, p. 156.—Téléobijectif Zeiss, fig. 15, p. 334.—Phototachéomètre Vallot, fig. 21, 18, p. 336-338.—Photogrammètre Deville, fig. 20, 21, p. 338.—Objectif Hermagis, fig. 39, p. 428.—Objectif Tessar, fig. 40, 41, p. 428.—Reconnaissances par cerfs-volants, p. 431-437; 439-449.—Appareil "Cailletet," à neuf chambres, fig. 47, p. 435.—Appareil Thilé, fig. 48, p. 436.—Reconnaissances par ballon captif. En cerf-volant, p. 450.—Reconnaissances sans carte, p. 404.—Reconnaissances en mer, p. 543-562.—Appareils téléphotographiques, p. 547.—Cylindrographe, fig. 68, p. 548; 554-556.—Reconnaissances maritimes par cerfs-volants, p. 562-568.—Appareil photographique, p. 566.

The above articles are reviewed by Captain Scheimpflug, in: Internationales archiv für photogrammetrie, Wien. Juli 1908, p. 141-145.

157 [SCHEIMPFLUG, THEODOR]

Der raketenapparat des sächsischen ingenieurs Maul. Int. Arch P., band 1, heft 3. Nov., 1908, p. 213-2-14.

158 SCHEIMPFLUG, THEODOR.

Ueber oesterreichische versuche drachenphotogramme zu erhalten und kartographisch zu verwerten, und deren bisherige resultate. Von k. k. Hauptmann und kapitän langer fahrt, Theodor Scheimpflug in Wien Illus. aer. M., v. viii, no. 3. März, 1904, p. 88-96, incl. 5 illus. LC(TL503 D4,v.8)

Experiments made in Austria, to obtain photograms by kites, and to apply them in map making.

Illustrations.—Fig. 1. Landschaftsbild, den abdruck einer mit photographierten libelle zeigend.—Fig. 2. Dreifacher panorama-apparat für küstenaufnahmen im

vorbeifahren.—Fig. 3. Siebenfacher drachenapparatus für vogelperspektiven mit aufgesetzten libellenkasten.—Fig. 4. Die Türkenschanz-baugründe mit der drachen-station.—Fig. 5. Die Döblinger.

159 SCHEIMPFLUG, THEODOR.

Zur stabilitäts-theorie der drachen. Von Th. Scheimpflug und Raimund Nimführ. Illus. aer. M., ix. jahrg., heft 10. Oct., 1905, p. 327-330, incl. 2 figs. LC(TL503 D4,v.9)

Treats on the theory of stability of kites.

160 SCHULZE, PAUL.

Leistungen und ziele der ballon photographie. Von dr. Paul Sheulze, Gardelegen. Kosmos, iv. Jahrg, heft 7, 1907, p. 220-222. LC(Q3K8,v.4)

161 SILBERER, HERBERT.

Die ballonphotographie. Wien. L. Z., ii. Jahrg., no. 4. April, 1903, p. 74-81. Sm.

162 SOREAU, M.

See La conférence de M. Soreau . . .

163 SPENCER, PERCIVAL.

Balloon photography at great altitudes. Aeron. J., v. v, no. 20, 1901, p. 61-62. LC(TL501 A35,v.5)

164 SPENCER, PERCIVAL.

Photography from balloons. Aeron. J., v. iv, no. 13, 1900, p. 103-105, incl. illus. LC(TL501 A35,v.4)

The same in: Ball. Aer. v. i, no. 2. Feb., 1907, p. 80-84, incl illus. LC(TL501 B25,v.1)

165 SPRUNG, A.

Die photographie als hülfsmittel zum studium der optischen erscheinungen der atmosphaere. Zeit. L., xi. Jahrg., heft 5, 1892, p. 142-143. LC(TL503 Z48,v.11)

Photography as an expedient for the study of optical phenomena of the atmosphere.

166 STOLZE, F.

Das mittel des ballonphotographen. Photog. N., 1890, p. 10, incl. 4 figs.

167 STOLZE, F.

Ueber ballonaufnahmen. Photog. N., vii. Jahrg., 1881, p. 325-330; 335-338, incl. diagrs. PO.

168 STOLZE, F.

Ueber die praktische ausführung photogrammetrischer aufnahmen. Photog. Woch. 7. Jahrg., 1881, p. 141-143; 149-151; 158-160; 166-168. PO.

169 TAUBEN- PHOTOGRAPHIE.

Aër. Club, x. Jahrg., no. 8. Aug., 1916, p. 120-121. Sm.

From "Die Luftflotte." A short history of the development of carrier-pigeon cameras.

170 THEILE, R.

Ueber präzise aufnahmen von plänen der niederungen grosser flüsse, ihrer mündungen und deltas mit hilfe der photographie und drachen-photographie. Jahrbuch für photographie und reproduktions-technik, Halle, a. S., 1903. p. 131-140. Sm.

Concerning precise sketching of plans of low-lands, of streams, their mouths and deltas with the aid of photography and kite photography.

171 TISSANDIER, GASTON.

Nouvelles expériences de photographie en ballon; ascension de MM. A. et G. Tissandier et P. Nadar. Acad. Sci., t. 103, juillet-déc., 1885, p. 224-225. LC(Q46A14,v.103)

172 TISSANDIER, GASTON.

La photographie en ballon. L'Aéron., xviiie année, no. 8. Août, 1885, p. 145-157, incl. 8 figs. N.Y. Sm.

Also in: La Nature, xiii année, 2 sémestre, no. 651. 7 juillet, 1885, p. 65-68; xiv année 2e sémestre, no. 687. 31 juillet, 1886, p. 120-122. LC(Q2N2,v.13-2:14-2) and in: Rev. aér., 1re année 1re livraison, janvier, 1888, p. 7-12, 2 plates. Sm.

173 TISSANDIER, GASTON.

La photographie aérienne par cerf-volant. Rev. l'Aér., ive année, 1re liv., 1891, p. 32, incl. 6 figs. Sm.

174 TISSANDIER, GASTON.

La photographie aérienne. La Nature, xviiie année, 1er sémestre, no. 876. 15 mars, 1890, p. 225-226, incl. 2 illus. N.M.

Relates to experiments of M. Batut with an apparatus attached to a kite for the purpose of taking photographs from the air.

Illustrations.—1. Vue perspective de Labruguiére. Tarn.—Facsimilé d'une épreuve photographique, obtenue au moyen d'un appareil enlevé par un cerf-volant à 90 m. de hauteur, le 29 mars 1889, à 11 heures du matin.—2. Appareil de M. Triboulet pour la photographie panoramique aériene par ballon captif non monté.

175 TISSANDIER, GASTON.

La photographie aérienne par cerf-volant. La Nature, xviie année 1er sémestre, no 825. 23 mars, 1889, p. 257-258, incl. 2 illus. N.M.

The editor of La Nature, M. Tissandier, reviews in this article the experiments made by M. Batut, at Enlaure, Tarn with a photographic apparatus, methods used, and results obtained.

Illustrations.—1. Le cerf-volant photographique, (showing camera in place).—2. Facsimilé d'une photographe obtenu à 127 m. d'altitude avec le cerf-volant photographique.

176 TISSANDIER, GASTON.

Sur des expériences de photographie en ballon. Acad. Sci., t. 101, juillet-dec., 1885, p. 187-189. Sm. LC(Q46A14,v.101)

177 DIE TRAGBARE DUNKELKAMMER. SYSTEM "HARDY".

Illus. aer. M., iv. Jahrg., 1900, p. 129, incl. 2 illus. WB.

Signed: Rieckeheer.

178 TRIBOULET, L.

La photographie en ballon. L'Aéron, xxxviiie, Année, no. 8. Août, 1905, p. 198-204, incl. 1 fig. 1 plate. N.Y. Sm.

179 UPSON, RALPH H.

Hundreds of kite balloons in the European war. Flying, v. v, no. 4. May, 1916, p. 158-160, incl. illus. LC(TL501 F7,v.5)

Illustrations show how kite-balloons are operated, how observations are made and the results thereof.

180 VERWENDUNG DER BALLONPHOTOGRAPHIE ZUR FORSTWIRT-SCHAFTLICHEN zwecken. D. Z. L., vi. Jahrg., heft 9, 1887, p. 285-286. LC(TL503 D4,v.6)

Application of balloon photography in economical forestry work.

181 VOYER, J.

Les applications militaires de la photographie en ballon. Par J. Voyer, capitaine du génie. Rev. G. S. P., v. xvi, no. 19. 15. octobre, 1905, p. 850-856, incl. 5 diagrs. LC(Q2R49,v.16)

Contents.—1. Considerations générales.—2. Méthodes et instruments.—3. Utilisation des photographies.—4. Conclusions.

182 WENZ, EMILE, i. e. WENZ-CHAPONNIERE, E.

Chambre noire pour photographie en cerf-volant ou ballon. (Communication faite à la réunion de la section ''Laussedat'' du 19 juin 1909) Soc. F. Phot., 11e année, iie série, t. xxv, no. 13. 1 juillet, 1909, p. 279-280, incl. 1 illus. LC(TR1S6,v.25,1909)

Illustrations: Chambre noire.

183 WENZ, EMILE.

Chambre noire Wenz-Hermagis pour photographie aérienne. (Séance générale du 16 décembre 1910). Soc. F. Phot., lviie année, 3e série, t. ii. Janvier, 1911, p. 47-48. LC(TR1S6,3.ser.,v.2)

184 WENZ, EMILE.

Dispositif permettant l'utilisation d'une chambre à main (du commerce) pour l'obtention automatique de photographies aériennes à l'aide de cerfs-volants. (Séance générale du 16 décembre 1910). Soc. F. Phot., lviie année, 3e série, t. ii. Janvier, 1911, p. 46-47. LC(TR1S6,3.ser.,v.2,1911)

185 [WENZ, EMILE]

Niveau à deux direction enregistrant l'inclinaison de l'axe optique et le déversement de la plaque. Int. Arch. P., band ii, heft 3. June, 1911, p. 216-218, incl. 1 fig.

Treats on the "Niveau Wenz" for aerial photography.

186 WENZ, EMILE.

Notes sur la photographie aérienne par cerf-volant présentées à la Société française de Navigation Aerienne. L'Aéron(xxxe année, no. 10, Oct. 1897, p. 219-231, incl. 6 outline figs., 3 half-tones. N.Y. Sm.

Illustrations.—Fig. 24. Dispositif pour le fonctionement de l'obturateur.—Fig. 26. Dispositif pour calculer les hauteurs verticales.—Fig. 25. Cerf-volant "Wenz" complet, avec dévidoir et récipient à accessories.—Fig. 27 Hôpital maritime à Berck-sur-Mer. Photographie par cerf-volant prise à 300 mètres.—Fig. 28. Quelques rues de Berck-sur-Mer. Photographie per cerf-volant prise à 275 mètres.

187 WENZ, EMILE.

La photographie aérienne par cerf-volant. Conq. L'Air. ive. ennée, no. 22, 24, nov., déc., 1907, p. 1-2; ve année, no. 1. Janvier, 1908, p. 8. Sm.

188 WENZ, EMILE.

La question de la photographie aérienne par cerf-volant. L'Aéron., xxxive année, no. 11, nov., 1901, p. 262, incl. 1 table. N.Y. Sm.

189 WENZ, EMIL.

Résumé historique de l'invention de la photographie aérienne par cerf-volant. L'Aéron., xxxive année, no. 6. Juin, 1901, p. 362. 1 double-page table. N.Y. Sm.

The same in: Soc. F. Phot., IIe série, t. xviii, no. 8. 15 avril, 1902, p. [210]-211. LC(TR1S6,v.18.)

This is a letter by author to the president of the French society of Aerial navigation including a table which shows the progress made in aerial photography by means of kites, up to 1901, in detail, and which also includes bibliographical notes.

190 WENZ, EMILE.

Sur la photographie aérienne par cerf-volant. Soc. F. Phot., iie série, t. vii, no. 11, nov., 1891, p. 409-414, incl. 1 illus. LC(TR1S6,2.ser.,v.7)

Illustration shows kite with camera in position and apparatus on the ground.

191 [WENZ, EMILE]

[Von der drachen-kamera]. Chambre noire pour photographie en cerf-volant ou ballon. Int. Arch. P., band ii, heft 3. juni, 1911, p. 215-216, incl. 1 illus.

At heading: "Aus der section 'Laussedat' du Société de photographie à Paris."

192 WERNER, A.

Drachenballons für kriegs-und expeditions-zwecke. Zeit. L., ii. jahrg., heft 1, 1883, p. 22-25. LC(TL503 Z48,v.2)

Kite balloons for war-and exhibition service purposes.

193 WERNER, A.

Das luftschiff im dienste des heeres. Zeit. L., ii. jahrg., heft 2, 1883, p. 50-54. LC(TL503 Z48,v.2)

The aerostat in service of the army.

194 DIE WETTBEWERBE DES AERONAUTIQUE-CLUB DE FRANCE.

Premier concours international de photographie aérienne. Illus. aer. M., ix. Jahrg., heft 6. Juni, 1905, p. 184-185. LC(TL503 D4,v. 9) Sm.

195 WILLIAMS, DION.

Photography from aircraft. By Colonel Williams, U. S. M. C. Mar. C. Gaz., v. ii, no. 2. June, 1917, p. 95-103. 10 plates (with 14 half-tones). ES.

Illustrations.—1. Original photograph taken with axis of the camera at an angle with the vertical.—2. The same view as that shown in fig. 1 with the angle of obliquity corrected.—3. The prospectograph copying camera.—4. The Scheimpflug combination aerial camera.—5. Original photograph from one combined exposure by Scheimpflug aerial camera.—6. The view showing in fig. 5. corrected for obliquity and combined into one view with scale correct.—8. The multiply airplane camera.—9. Operating mechanism of multiple airplane camera.—10. Photograph taken with multiple airplane camera at an altitude of 4,000 to5,000 ft.—11. Photograph taken by multiple airplane camera enlarged four times.—12. Projecting lantern with electrical connections.—13. The Eastman Kodack airplane camera.—14. Imperial city Peking, China, from an elevation of 600 ft.

196 WISE, HUGH D.

Experiments with kites. Cent. M., v. liv, new series, v. xxxii, no. 1. May, 1897, p. [78]-86, incl 9 illus. LC(AN,v.34,n.s.)

Sub-title: Including an account of the writer's ascent from Governor's Island, N. Y. H.

197 WISE, HUGH D.

Wise's photographic kite. By Lieut. H. D. Wise, 9th U. S. Infantry. Aeron. J., v. ii, no. 7. July, 1898, p. 63-64, incl. 2 illus. LC(TL501 A35,v.2)

Illustrations.—Fig. 1. Wise's kite-photographic apparatus.—Fig 2. Map [taken from kite camera].

INDEX.

PROFESSIONAL MEMOIRS

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SUPPLEMENT No. 2
PROFESSIONAL MEMOIRS
NOVEMBER-DECEMBER, 1918.
VOL. X, No. 54.

Screw Threads

Bibliography of Available Material on the Systems, and Classification of Screw Threads, including Tolerances, Allowances and Symbols of Nomenclature; and on Gages, Methods of Testing, and Specifications. [August to October, 1918.]

Prepared at request of the U. S. Screw Thread Commission and arranged in alphabetic order according to Authors and Titles, and with an Index.

By

HENRY E. HAFERKORN
Librarian,
Engineer School Library.

PREFATORY NOTE.

The aim of this Bibliography is to furnish accounts as complete as possible, of the various domestic and foreign forms and systems of screw threads, together with reports of professional men, relating to their actual experience and study along these lines.

It is not the purpose to furnish a list of patents or titles of text-books containing treatises on screw threads for the different trades and professions, but a comprehensive view of existing conditions.

With this point in view, and with the earnest desire to assist to the greatest extent the Commission in its labors, more than 500 volumes of books, periodicals and society transactions have been examined.

Considerable difficulties have been met in obtaining the proper sources, some of which could not be found in local libraries or, when found, were not available.

It will be noted that the modern heading of the Engineering Standards Committee of London is now, British Engineering Standards Committee, its publications being published by the British Engineering Standards Association. The old form has been retained in case of such titles as were originally printed under that heading, and would naturally be entered accordingly in the library catalogues.

The present simple form of arrangement of this Bibliography, with an index, was adopted because it was considered the most convenient and it is hoped will meet with approval.

Accuracy in the smallest details of the individual entries has been sought. There may be found, however, errors or inaccuracies not detected during the revision of copy or during proofreading. The undersigned will be very grateful if such mistakes are made known to him, so that they may be corrected in another issue of this publication.

November 25, 1918.

H. E. Haferkorn.

ABBREVIATIONS.

The initials at the end of titles refer to Libraries where the publications will be found, viz: Bur. St., U. S. Bureau of Standards, Dept. of Commerce, Washington, D. C.; CE: Library, American Society of Civil Engineers, 29 W. 39th St., New York City; E: Library, Engineering Societies, 29 W. 39th St., New York City; ES: Engineer School Library, Washington Barracks, D. C.; LC: Library of Congress, Washington, D. C.; P.O.: U. S. Patent Office, Scientific Library, Washington, D. C.; ES.—Pam. signifies that the article has been clipped and pasted in a scrap-book, filed as pamphlet.

Titles to which no initials are affixed have not been located in Libraries available to us.

Publications found in the LC., show the call-number in each case for the convenience of the reader, and the Library staff, for instance Title number 153: Jeffcott. Notes on screw threads, LC., meaning Library of Congress, (TJ1 I 5, pts. 3-4, 1907), the notation in parenthesis represents the call-number, which is needed to locate the publication on the shelves of the Library of Congress.

ES—Pam. signifies that the article has been clipped out and pasted in a scrap-book, filed as pamphlet.

SCREW THREADS.

Bibliography of available material on the Systems, and Classification of Screw Threads, including Tolerances, Allowances and Symbols of Nomenclature; and on Gages, Methods of Testing, and Specifications. Prepared at Request of the U. S. Screw Thread Commission and Arranged in Alphabetic Order According to Authors and Titles, and With an Index by Mr. Henry E. Haferkorn, Librarian, Engineer School Library, Washington Barracks, D. C., August to October, 1918.

ABBREVIATIONS.

For periodicals, society papers, and other serial publications the following abbreviations have been adopted, viz:

Am. E. R. J.: American Engineer and Railroad Journal, New York.

Am. I. M. E.: American Institute of Mining Engineers, New York. Transactions.

Am. Mach.: American Machinist, New York.

Am. Ry. M. M. A.: American Railway Master Mechanics' Association, Chicago. Reports of proceedings.

Am. Soc. M. E.: American Society of Mechanical Engineers, New York. Journal; Transactions.

Am. Soc. T. M.: American Society for Testing Materials, Philadelphia, Pa. Proceedings.

Autom. Ind.: Automotive Industries, New York.

Cass. E. M.: Cassier's Engineering Monthly, London.

Elec. W.: Electrical World, New York.

Eng.: Engineering, London.

Engi.: The Engineer, London.

Eng. N.: Engineering News, now changed to Engineering News-Record, New York.

Frank. I.: Franklin Institute, Philadelphia. Journal.

Inst. Civ. E.: Institution of Civil Engineers, London. Minutes of proceedings.

Génie C.: Le Génie Civil, Paris.

Hist. E. R.: History and early reports of the Master Car Builders' Association.

Horseless A.: Horseless Age, New York. (Since July, 1918 merged with Automotive Industries, N. Y.)

Inst. Aut. E.: The Institution of Automobile Engineers, London. Proceedings.

Inst. Mech. E.: Institution of Mechanical Engineers, London.

Iron Age.: Iron Age, New York.

J. Ry. App.: Journal of Railway Appliances, New York.

Mach. Eng. ed.: Machinery, New York. Engineering edition.

Mach. Shop ed. Machinery, New York. Shop edition.

Mach.: Machinery (general edition), New York.

Master C. B. A.: Master Car Builders' Association, Chicago.

Mech. Eng.: Mechanical Engineer, Manchester, England.

Mech. W.: Mechanical World, London.

Monthly C. R.: U. S. Monthly Consular Reports. Dept. of Commerce and Labor, Bureau of Statistics, Washington, D. C.

N. Phys. L.: National Physical Laboratory, Teddington, England. Collected researches.

Power: Power, New York.

P. Eng.: Practical Engineer, London.

Ry. Mach.: Railway Machinery, New York. (Now changed to Machinery.)

Ry. Mech. E.: Railway Mechanical Engineer, New York.

Ry. R.: Railway Review, Chicago.

Rev. M.: Revue de Mécanique, Paris.

Rev. Tech.: La Revue Technique, Paris.

Sci. Am.: Scientific American, New York.

Sci. Am. S.: Scientific American Supplement, New York.

Soc. Autom. E.: Society of Automotive Engineers, New York. Journal; Transactions.

S. E. I. N.: Société d'encouragement pour l'industrie nationale, Paris.

Tech. M.: Technique Moderne, Paris.

V. D. I.: Zeitschrift des Vereins deutscher Ingenieure, Berlin.

Z. O. I. A.: Zeitschrift des Oesterreichischen Ingenieur-und Architekten Vereins, Wien.

Zeit. Werkz: Zeitschrift für werkzeugmaschinen und werkzeuge, Berlin.

A. BOOKS.

1. AUBAILE, ALEXIS.

Filetages universels systéme Aubaile. Paris, 1904.

2. CASTNER, J.

Der schraubenverschluss mit plastischer liderung und der keilverschluss mit huelsenliderung fuer geschuetze. Reprinted from "Schiffbau," no. 5, Dec. 13, 1905.

See review of this pamphlet in: (Eng.), v. lxxxv, Jan. 3, 1908, p. 6-7.
ES. 15328 LC.(TA1,E55,v.85)

Brief review of the screw breech block in the French service, followed by statements relating to the wedge-block designed by Krugg in 1859. Author favors th latter owing to its greater mechanical simplicity. See also: Screw and wedge breech-mechanism (Eng.), Feb 14, 1908, p. 207, under no. 244.

3. COLVIN, FRED. HERBERT.

Jigs and fixtures. A reference book showing many types of jigs and fixtures in actual use, and suggestions for various cases. By Fred H. Colvin and L. L. Haas. N. Y., McGraw-Hill book co., 1913.
ES 20275 LC(TJ1185 C68)

Chap. xi. Designs of and materials for gages, p. [117]-133. Chap. xii. External and internal thread gages, p. [134]-141. Chap. xiii. Miscellaneous manufacturing gages, p. [141]-152.

4. COLVIN, FRED. HERBERT, comp.

Screw machine kinks, comp. by F. H. Colvin and F. A. Stanley, New York [etc.], Hill pub. co., 1908.

3 p. l., 88 p. illus. diagrs. 16cm. (Half-title: The Hill kink books.)
Originally pub in Am. Machinist. LC.(TJ1222 C67)

5. COLVIN, FRED. HERBERT, comp.

Screw thread kinks, comp. by F. H. Colvin and F. A. Stanley. New York, Hill pub. co., 1908.

3 p. l., 107 p. illus., fold. tables, diagrs. 16cm. (Half-title: The Hlil kink books. LC.(TJ 1222 C68)

Originally pub. in the Am. Machinist.

6. ENGINEERING STANDARDS COMMITTEE, London.

British standard pipe threads for iron or steel pipes and tubes. Leslie S. Robertson, M. Inst. C. E., secretary. Lond., C. Lockwood & son, 1905, LC. (TJ415E5).

8 numbered leaves, tab., diagrs. 33cm. ([Report] no. 21.)

At head of title: Report issued by the Engineering standards committee . . .

Report of the committee on screw threads and limit gauges.

7. ENGINEERING STANDARDS COMMITTEE, London.

British standard screw threads. Leslie S. Robertson, M. Inst. C. E., secretary. Lond., C. Lockwood & son, 1905.

8 numbered leaves. iv tab., 2 diagrs. 33cm. ([Report] no. 20.) LC(TJ1 340E5)

At head of title: Interim report issued by the Engineering standards committee . . .

Printed on one side of leaf only.

Report of the Committee on screw threads and limit gauges.

8. ENGINEERING STANDARDS COMMITTEE, London.

British standard screwing for marine boiler stays. Leslie S. Robertson, secretary. Lond., pub. at the offices of the committee, Westminster, 1913.

2 leaves, 33cm. ([Report] no. 62.) Dated Aug., 1913. Bur. St.

9. ENGINEERING STANDARDS COMMITTEE, London.

British standard screw threads and pipe threads. Leslie S. Robertson, secretary. Westminster, offices of the committee, 1906. LC(TJ1340 E6)

4 p. 33cm. ([Report] no. 34.)

10. ENGINEERING STANDARDS COMMITTEE, London.

British standard specification for copper-alloy three-piece unions for low and medium pressure British standard screwed copper tubes (primarily for domestic and similar work). . . . Lond., pub. for the committee by C. Lockwod & son, 1914.

19 numbered leaves, illus. 33cm. ([Report] no. 66.) LC.(TS 280 E58)

Leslie S. Robertson, sec'y.

11. ENGINEERING STANDARDS COMMITTEE, London.

British standard specification for copper tubes and their screw heads (primarily for domestic and similar work). Lond., pub. for the committee by C. Lockwood & son, 1913.

16 numbered leaves, incl. tables, diagrs. 33cm. ([Report] no. 61. LC. (TS 280 E6)

12. ENGINEERING STANDARDS COMMITTEE, London.

Combined reports on British standard screw threads. Leslie S. Robertson, secretary. London, pub. for the committee by C. Lockwood & son, 1907.

42 leaves, incl. illus., tables, diagrs. 33cm. ([Report] no. 39.) LC.(TJ 1340 E4)

Various paging.

Contents.—[Report] no. 20. British standard screw threads. 1905.—[Report] no. 28. Report on British standard nuts, bolt-heads, and spanners. 1906. [Report] no. 38. Report on British standard systems for limit gauges for screw threads.

13. Engineering Standards Committee, London.

Report on British standard dimensions for sparking plugs for internal combustion engines. Revised Sept., 1917. Lond., pub. for the committee by C. Lockwood & son, 1917.

12 p. illus. 22cm. ([Report] no 45, 1917.) LC.(TJ787,E5,1917)

This report supersedes Report no. 45, and the interim report (c. I. 2877) issued in Dec., 1915.

14. Engineering Standards Committee, London.

Report on standard dimensions for the threads of sparking plugs (for internal combustion engines). Leslie S. Robertson, secretary. Lond., pub. for the committee by C. Lockwood & son, 1909.

7 numbered leaves, incl. tables, diagr. 33cm. ([Report] no. 45.) LC.(TJ 787 E5)

15. Engineering Standards Committee, London.

Report on British standard heads for small screws. Leslie S. Robertson, M. Inst. C. E., secretary. London, pub. for the committee by C. Lockwood & son, 1911.

9 numbered leaves. incl. tables, diagrs. (tab., fold.), 33 cm. ([Report] no. 57.) LC.(TJ1340 E65)

16. Engineering Standards Committee, London.

Report on British standard nuts, bolt-heads, and spanners. Leslie S. Robertson, M. Inst C. E., secretary. Lond., pub. for the committee by C. Lockwood & son, 1906. LC(TJ 1330 E6)

11 numbered leaves, incl. illus., iv tables. 33cm. ([Report] no. 28.)

Preface signed: H. F. Donaldson, chairman of the sectional committee on screw threads and limit gauges.

17. Engineering Standards Committee, London.

Report on British standard systems for limit gauges for screw threads. Leslie S. Robertson, secretary. Lond., pub. for the committee by C. Lockwood & son, 1907.

19 numbered leaves, incl. illus., tables, diagrs. 33cm. ([Report] no. 38.) LC.(TJ 1340 E55)

Preface signed: H. F. Donaldson, chairman of the sectional committee on screw threads and limit gauges.

18. Engineering Standards Committee, London.

Report on British standard threads, nuts and bolt heads for use in automobile construction. Leslie S. Robertson, secretary. Lond., pub. for the committee by C. Lockwood & son, 1911.

10 numbered leaves, incl. tables, diagrs. 33 cm. ([Report] no. 54.) LC.(TL275 E6)

19. Ferrus, L.

Culasses à vis et culasses à coin. Par L. Ferrus, L'armée française. Paris, Berger-Levrault et cie., 1908.

Reprinted form "Revue d'Artillerie," Jan., 1907.
See review in: (Eng.), v. lxxxv, Jan. 3, 1908, p. 6-7.
ES. 15328 LC.(TA1,E55,v.85)

Major Ferrus discusses the merits of the screw and wedge breech-blocks, and is in favor of the first.

His essay is an answer to the paper by Mr. J. Castner.

20. Franklin Institute, Philadelphia.

The Sellers or Franklin Institute system of screw-threads. A correspondence growing out of an inquiry addressed to the Institue by the Society of German Engineers. . . . [Philadelphia, 1887.]

Cover-title, 16 p. 23cm. LC.(TJ 1340 F8)
"Reprinted from the Journal of the Franklin Institute, April, 1887."

21. Gentry, G.

Standard guide to screw threads. Lond., N. Y., E. and F. N. Spon [etc.], 1907.

77 p. illus., 23cm.

22. Great Brit. War Office. Committee on standard leading screws for screw-cutting lathes.

Report of a committee appointed to consider the provision of standard leading screws for screw-cutting lathes. . . . Lond., printed for H. M. Stat. off., by Harrison & sons [1905].

24 p. plates, diagrs. (part fold.) plan. 33 cm. LC.(TJ1340 G7)
H. F. Donaldson, president.

23. Grimshaw, Robert.

Shop kinks. ed. 4. N. Y., N. W. Henley pub. co., 1904.
ES 3222 LC(TJ1165 G88)

Screw-threads, p. 147, 148, 187.

24. Hamilton, Douglas Thomas.

Automatic screw machines. A treatise on the construction, design, and operation of automatic screw machines and their tool equipment. By D. T. Hamilton and Franklin D. Jones. N. Y., Industrial press, 1916.
ES 23561 LC(TJ1215 H3)

Contents.—Chap. i. Screw classification and development, p. 1-10. Chap. ii. Single-spindle automatic screw machines, p. 11-38. Chap. iii. Multiple-spindle automatic screw machines, p. 39-83. Chap. iv. Automatic screw machine tool equipment, p. 84-147. Chap. v. Adjusting or setting-up automatic screw machines, p. 148-196. Chap. vi. Attachments for automatic screw machines, p. 197-223. Chap. vii. Designing screw machine cams, p. 224-257. Chap. viii. Operations on single- and multiple-spindle screw machines, p. 258-335.

25. Hamilton, Douglas Thomas.

Gages and gaging inspection. N. Y., Industrial press, 1918.
viii [1], 295 p. 23 cm. ES LC

Contents.—Chap. i. Reference standards and measuring machines, p. 1-27. Chap. ii. Limits and tolerances, p. 28-46. Chap. iii. Reference, working and inspection gages, p. 47-88. Chap. iv. Profile gages, p. 89-105. Chap. v. Indicating gages, p. 106-107. Chap. vi. Gaging and inspecting screw threads, p. 198-253. Chap. vii. Gaging and inspecting gears, p. 254-283.

26. HARTNESS, JAMES.

Hartness flat turret lathe manual. A handbook for operators. Springfield, Vt., Jones & Lamson machine co., 1914.

ES 20785 LC(TJ1218 H36, 1914)

"Die-cut screw threads," p. 134-135.

27. HOLTZAPFFEL, CHARLES.

Turning and mechanical manipulation. Intended as a work of general reference and practical instruction on the lathe and the various mechanical pursuits followed by amateurs. Lond., 1850-56.

3 vols., illus., diars. 23cm. ES 6679-81 LC (TT145 H7)

v. 2, Chap. xxvi. Screw-cutting tools, p. 577-655.—Section ix. Screw threads considered in respect to their proportions, forms, and general character, p. 655-681.

27a Machinery's Screw Thread Book.

Compiled and edited by C. Edgar Allen. . . . Price, 2s 6d net. Lond., The Machinery pub. co., ltd. [1918?].

63 p. incl. illus., diagrs., tables, 22cm. Bur. St.

A very convenient reference book giving the standard screw thread systems employed in Great Britain, America and on the European continent, as well as some standards of large concerns in England, never published before.

28. MANVILLE, THE E. J., MACHINE CO., Waterbury, Conn.

The art of screw thread rolling. Notes on its origin, development, scope and practical utility, with comparative tables and illustrations. . . . Waterbury, Conn. The E. J. Manville machine co. [c1905].

1 p. l., [5]-24 p. illus., tables, diagrs. 23cm. LC. (TJ. 1222, M29.)

29. THE NATIONAL PHYSICAL LABORATORY [Teddington].

Notes on screw gauges. Teddington, Eng., printed and published by W. F. Parrott, The Causeway [1916].

28 p. incl. diagrs., sections, tables. 33cm. Bur. St.

Enlarged issue i. Feb., 1916, price 1s. 6d.

Contents: Notes on the production and testing of screw gauges.—i. The need for accuracy in a gauge.—2 Verification of screw gauges.—3. Errors of screws.—4. Measurement of the diameters of plug screws.—5. Notes on tools.—6. Measurements of ring screw gauges.—7. Measurements at the lathe.—8. Pitch. —9. Measurement of angle of plug screws.—10. Measurements of effective diameter and angle by cylinders of other than "best" diameters.—11. Date for effective and core diameter measurements.—12. Use of a reference groove and cylinder for effective and core diameter measurements.

30. REULEAUX, FRANZ.

The constructor, a handbook of machine design. Authorized trans., complete and unabridged from the 4th enl. German ed., by H. H. Suplee. Phila., H. H. Suplee, 1893.

xviii, 312 p. front. (port.). illus. 31cm. LC. (TJ230, R.46.)

Chapter iv was reprinted in: Mechanics, Phila., Sept.-Oct., 1890.

LC. (TA1E595, 1890.)

Chapter iv: Bolts and screws. §73. Geometrical construction of the screw thread. §74. Dimensions of V screw threads. §75. The Whitworth screw system. Whitworth pipe thread scale, p. 214-218.—§76. Sellers' screw thread system. §77. Metrical screw systems. §78. Metrical screw thread systems: Delisle i. Pfalz-Saarbueck and Delisle ii. §79. New systems. §80. Nuts, washers and bolt heads. §81. Table and proportional scale for metrical bolts and nuts. §82. Weight of round iron. §83. Special forms of bolts. §84.

Wrenches. §85. Nut locks, p. 214-217. (Paging belongs to article reprinted from chapter iv in "Mechanics.")

31. Screw Thread Cutting. . . .
New York city, The Industrial press, c 1909.

40 p. diagrs. 23cm. (Machinery's reference series .. no. 32.)
Contents.—Introduction.—Change gears for thread cutting, by E. Oberg. —Kinks and suggestions in thread cutting.—Tables and formulas for making thread tools, by A. L. Valentine, E. Oberg, and J. M. Stabel.
LC. (TJ. 1222. S3.)

32. Screw Thread Tools and Gages. . . .
New York, The Industrial press, c 1909.

42 p. diagrs. 23cm. (Machinery's reference series .. no. 31.)
Contents.—Screw thread systems, by E. Oberg.—Making thread tools, by E. A. Johnson.—Tools for accurate thread cutting, by J. M. Stabel.—Making thread gages, by A. L. Monrad.—Measuring screw thread diameters, by W. Cantelo. LC. (TJ. 1222. S34.)

32a Society of Automotive Engineers., N. Y.
Screw-thread, bolt and nut standards. N. Y., Society, 1918.

14 l. (4 mimeographed), incl. diagrs., tables. 22cm. Bur. St.
Preamble signed Sept. 26, 1918.

33. [Society of Automotive Engineers., N. Y.]
Standards and data sheets. [N. Y., Society, 1917.]
Loose sheets in loose leaf binding covers. 2 vols. 19cm.
LC. (TL. 151, S6.)

The Acme standard thread. Comparison of Acme and square threads v. i, 6aa; Constants for finding diameter at bottom of thread v. i, 6b; International (metric system) standard 60 c thread v. i, 6c; Screws and bolts. S. A. E. standard v. i, 4; 4a; S. A. E. Large diameter thread standard v. i, 4c; Screws and bolts. (J. A. Anglada and E. H. Ehrman v. i, 4b; Spark-plug shells. S. A. E. standards v. i, 3; U. S. Standard bolts, nuts and washers, (Anglada) v. i, 6; Whitworth standard thread v. i, 6a; Drill sizes for standard threads v. i, 6d; Standardization of pipe thread gages (Machinery), v. ii, 40a.
For further details consult index (revised to May, 1917,) in front of vols., under—under headings "Screws," "Thread."

34. U. S. Bureau of Steam Engineering.
Report of the board to recommend a standard gauge for bolts, nuts, and screw-threads for the United States Navy. May, 1868. Wash., Govt. Print. Off., 1880.
30 p. 19 plates (2 fold.) iv tables. 24cm. LC. (TJ. 1340, U5.)

35. U. S. Bureau of Supplies and Accounts (Navy Dept.).
Specifications for machine screw. Jan. 23, 1897. Wash., Govt. Print. Off., 1897.
1 p. 24cm.

36. U. S. Congress. House. Committee on Coinage, Weights and Measures.
Hearing . . . "to provide for the appointment of a commission to standardize screw-thread tolerances," on H. R. 29292. Jan. 27, 1917; Feb. 5, 1917. Wash., Govt. Print. Off., 1917.

Cover-title, 29 p. 23cm. (House of Representatives. 64th Cong., 2d sess.)
ES. 25105. LC. (TJ. 1340, U5, 1917.)

Contents.—Statement of Hon. J. Q. Tilson.—The same of Dr. S. W. Stratton. —The same, of Mr. Frank O. Wells.—The same, of Mr. E. H. Ehrman.—The same, of Mr. Coker F. Clarkson.—The same, of Mr. Earl Wheeler.—The same, of Dr. Stratton.—The same, of Capt. William Strother Smith, U. S. N.—The same, of Horace K. Jones.—The same, of F. O. Wells.

[Appended] Notes on screw gauges. By Col. R. E. B. Crompton, past president, Institution of Automobile Engineers, p. 20-27.

Contents.—Nomenclature.—A short history.—Intoduction to the Whitworth thread.—Introduction of the B. A. System.—Discovery that the Whitworth system itself was not really interchangeable, and the British Standard Committee formed to consider this matter.—Synopsis of work carried out by the Standards Screw Gauge Committee up to issue of report no. 38.—Difficulties in gauge making—Rounded crests and roots versus flat crests—Gauging—Gauges proposed in report no. 38.—Difficulties experienced in obtaining such gauges in quantity.—Issue by National Physical Laboratory of several papers dealing with the gauge difficulty.—Tolerances on screwed work must include allowances.—Effects of excessive tolerance on strength.—Effect of clearances.—Adoption of high-crested taps.—Division of gauges into two classes.—Means by which wear of gauges can be met.—Gauging nuts.—Angle and forms of thread.

37. U. S. Congress. House. Committee on Coinage, Weights and Measures.

Hearings . . . on commission to standardize screw threads. 65th Cong., 2d sess., on H. R. 10472. March 5, 7, 1918. Wash., Govt. Print. Off., 1918.

ES 25104 LC(TJ134OU5, 1918)

25 p. 23cm.

Hon. William A. Ashbrook, Chairman of committee.

Contents.—Statement of Hon. Loren E. Wheeler— . . . of Hon. John Q. Tilson— . . . of Mr. John G. Utz— . . . of Rear Admiral W. Strother Smith, U. S. N.— . . . of Dr. S. W. Stratton— . . . of Mr. F. O. Wells— . . . of Mr. Herbert Chase.

Appended: U. S. 65th Cong. 2d sess. House.

Report no. 407: Commission to standardize screw threads. Mr. Goodall, from Committee on Coinage, Weights, and Measures, submitted . . . report [to accompany H. R. 10852.] 2 pages. 23cm.

38. Van Dervoort, Wm. H.

Modern machine shop tools. N. Y., N. W. Henley pub. co., 1903.

ES 2096 LC(TJ1185, V24)

Screw threads, p. 88, 127, 125, 128, 129.

39. Whitworth, Sir Joseph, 1st bart.

Miscellaneous papers on mechanical subjects. By Jos. Whitworth, F. R. S. Lond., Longman, Brown, Green, Longmans, and Roberts [etc., etc.], 1858.

viii, 183, [1] p. 2 col. plates 22cm. LC. (T7. W62.)

Contents.—A paper on plane metallic surfaces or true planes.—A paper on an uniform system of screw threads.—Address delivered to the Institution of mechanical engineers, Glasgow, 1856.—A paper on standard decimal measures of length.—Rifled fire-arms.—

Appendix: New York industrial exhibition, 1853. Official report.

40. Whitworth, Sir Joseph, 1st bart.

Appendix to miscellaneous papers on mechanical subjects: Guns and steel. [Manchester, 1873.]

Caption-title, 43, iii p. illus. 25cm. (At head: For private circulation.) Signed at end of paper: Joseph Whitworth & Co., Manchester, 1873.

LC. (T7, W62.)

Contents.—Principles of rifling guns.—Special committee on rifled cannon.—Report of trials on penetration.—Penetration of armour plating in 1858.—Report on 7-in. wrought iron guns, rifled on various systems.—The report of the

special Armstrong and Whitworth committee.—Correspondence relating to 7 and 8-in. guns.—Correspondence with Sir John Pakington.—Correspondence relating to the Whitworth metal—Correspondence on the subject of field guns for the Indian service.—Report on the trials of a 9-in. Whitworth rifled gun. Correspondence relating to a 12-in. gun.—Report on Sir J. Whitworths' Works at Manchester.

B. PERIODICALS.

SOCIETY PAPERS, AND OTHER SERIAL PUBLICATIONS.

40b Allowances and Tolerances.

(Mach.), v. xxi, no. 6. Feb., 1915. p. 486. 350 words.

LC(TJ1 M21, v. 21)

41. [American Railway Master Mechanics' Association.

Screw threads. Standards adopted by Am. Railway Master Mechanics' Assoc'n (Am. Ry. M. M. A.) v. xxxiii, 1900, p. 371-381. 19 figs (diagrs., etc.), 4 tables. ES 25100

42. [American Railway Master Mechanics' Association.]

Standards and recommended practice. (Am. Ry. M. M. A.), v. 47, part 1, 1914, p. 463-466. Diagrs., sections, tables. ES 25101

Screw threads, bolt heads and nuts. Standard, p. 463-466.

Proportions for Sellers' standard nuts and bolts.

43. [American Railway Master Mechanics' Association.]

Report of committee on dimensions for flange and screw couplings for injectors. (Am. Ry. M. M. A.), v. xlviii, 1915, p. 420-438. With discussion, incl. 22 sections, 4 tables, 1 fold. plate (sections).

LC. (TF 1, A5, v. 48.)

Discussion, p. 432-438.

Committee: M. H. Haig, chairman; members: T. F. Barton, S. B. Andrews, W. H. Winterrowd, B. F. Kuhn.

Contents.—Form and dimensions of thread.—Dimensions of coupling nuts and sleeves.—Application of coupling sleeves.—Dimensions of flange couplings.—Opinions on brazed and mechanical joints.—Comments on flange connection as compared with spanner nut.—Material in coupling nuts and sleeves.—Reinforced spanner nuts.—Spelter.—Brazing.—Brazing by oxy-acetylene process.—Material in injector pipes.—Application of injector equipment.—Lever starting valve support.—Use of standards.

44. American Railway Master Mechanics' Association.

Report of the Committee on dimensions for flange and screw couplings for injectors. (Am. Ry. M. M. A.), v. xlix, 1916, p. 63-70.

LC. (TF 1, A5, v. 49.)

Committee: M. H. Haig, chairman; members: T. F. Barton, W. H. Winterrowd, B. F. Kuhn, S. B. Andrews, M. D. Franey, J. C. Mengel.

45. American Railway Master Mechanics' Association.

Forty-ninth annual convention. (Ry. R.), v. 58, No. 26, June 24, 1916, p. 923-940. Port. ES.

Port.: William Schlafge, president of the association.

Standardization of screw threads, p. 926-927. (Being an abstract of a paper read by F. O. Wells, of the Greenfield Tap & Die corporation). 1 table.

46. [American Society for Testing Materials.]

Report of Committee E-3 on Revision of pipe threads. (Am. Soc. T. M.), v. xvii, part i, 1917, p. 504-507.

ES. 24942. LC. (TA401 A5, v. 17-1.)

H. V. Willie, chairman of committee.

The above committee was forming part of a joint committee on this subject with committees of the following societies: Am. Gas Institute; Am. Society of Mech. Engineers; Manufacturer's Association on Standardization of Fittings; Master Car Builders' Association; Railway Signal Association.

46a. [AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.]
Adjustable tolerances for bolts, nuts, screws and taps. (Iron Age), v. xcv, no. 6. Feb. 11, 1915, p. 377. LC. (T1 I7, v. 95.)

''A conference looking to the settlement of the tolerances which should be allowed in the departure from exact standard size of bolts, nuts, screws and taps was held at the rooms of the Am. Society of Mechanical Engineers in New York city, on Friday morning, Feb. 5th.''

Question before the meeting was ''Screw thread fits for products one-fourth inch, to 2 inch. diam.,'' one that had been under consideration for several years. Letters were propounded and answered, on allowable departure from U. S. Standard pitch diameter, root diameter, outside diameter, lead of thread, and angle of thread.

46b. [AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.]
Commission to standardize screw threads. (Am. Soc. M. E.) Journal, v. 40, no. 10. Oct., 1918, p. 875. 310 words.
ES. LC. (TJ1, A72, v. 40.)

Deals with the preliminary work of the newly created screw thread commission which will make its headquarters at the Bureau of Standards, Washington, D. C.

47. [AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.]
Report of A. S. M. E. Committee on limits and tolerance in screw thread fits. (Am. Mach.), v. 48, no. 22, May 30, 1918, p. 913-926, incl. 18 figs. (diagrs., sections, etc.), tables 1-20, and formulas.
ES. LC. (TJ1, A7, v. 48.)

This report is the result of a comprehensive investigation by the committee on limits and tolerances in screw thread fits, of the A. S. M. E., and was presented to the Society at Worcester, Mass., June 4-7, 1918.

An excerpt of the above in: (Mach.), v. 24, July, 1918, p. 1061-1062.

47a. [AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.]
Report of the Committee on standardization of flanges and pipe fittings. (Am. Soc. M. E.) Journal, v. 40, no. 10. Oct., 1918, p. 850-852, incl. 2 figs., tables 1-4. ES. LC. (TJ1, A72, v. 40.)

Committee: Arthur R. Bayliss, acting chairman. Members: Stanley G. Flagg, jr., E. M. Herr, Arthur M. Houser, Julian Kennedy, E. A. Stillman, A. S. Vogt, R. M. White.

The committee has agreed on additions to existing standards comprised in its report known as the American standard for pipe flanges, fittings and their bolting, issued in 1914.

The above paper was prepared under direction of J. P. Sparrow, deceased, the late chairman of the committee.

48. [AMERICAN SOCIETY OF MECHANICAL ENGINEERS, N. Y.]
Report of the Committee on standardization of special threads for fixtures and fittings. Rolled threads for screw shells of electric sockets and lamp bases. Papers no. 1474. (Am. Soc. M. E.), v. 37, 1915, p. [25]-29, incl. 4 figs., tables.
ES. 23670. LC. (TJ1, A7, v. 37.)

Received by the council, A. S. M. E., Feb. 13, 1915, and ordered printed. Presented at the spring meeting, Buffalo, June, 1915, of the A. S. M. E.

Committee: Edw. S. Sanderson, chairman. Members: Wm. J. Baldwin, Stanley G. Flagg, jr., C. R Hare, H. E. Harris, A. H. Moore, W. R. Webster, Geo. B. Thomas, secretary.

49. [American Society of Mechanical Engineers, N. Y.]

Standardization of pipe thread gages. Paper no. 1399. (Am. Soc. M. E.), v. 35, 1913, p. 309-311. 1 fig., 1 table.

ES. 21805. LC. (TJ1, A7, v. 35.)

Fig. 1 view of plug and ring gage.

Report of a committee on the above subject presented at annual meeting, 1913. E. D. Meier, chairman of committee.

50. [American Society of Mechanical Engineers, N. Y.]

Standardization of threads of sockets and lamp bases. (Elec. W.), v. 67, no. 5, Jan. 29, 1916, p. 260. 1 fig., 1 table.

ES. LC. (TK1E5, v. 67.)

Recommendations of Am. Soc. Mech. Engineers on design of screw-shell lamp threads for lamp bases, fuse plugs, attachment plugs and the like.

See also under title: Rolled threads for screw shells.

51. [American Society of Mechanical Engineers, N. Y.]

Standard proportions for machine screws. Revised report of the Committee on Standard proportions for machine screws. Paper no. 1142. (Am. Soc. M. E.), v. 29, 1907, p. [99]-113, 2,500 words, incl., table no. 1-14; 1-2. 1 fold. plate (diagr.)

ES. 12238. LC. (TJ1, A7, v. 29.)

Committee: Wilfred Lewis, chairman. Members: Chas. C. Tyler, Horace K. Jones, John Riddell, Geo. R. Stetson, Geo. M. Bond.

History of committee, p. 114.—Automobile Association standard bolts and nuts, p. 119.—(Material, tolerance, p. 120.) (Length of threaded portion, p. 121).

52. [American Society of Mechanical Engineers, N. Y.]

Standard threads for hose couplings. Report of Sub-committee on fire protection. Paper no. 1398. (Am. Soc. M. E.), v. 35, 1913, p. 301-307, 4 figs. ES. 21805. LC. (TJ1, A7. v. 35.)

Presented at annual meeting, 1913. John R. Freeman, chairman of committee.

53. Anderson, C.

Using taper wedges in cutting square threads. (Mach.), v. xxiv, March, 1918, p. 644-645, incl. 2 figs. (diagrs.)

ES. Pam. LC. (TJ1, M2, v. 24.)

54. Anderson, W. S.

Tools for turning and threading small screws. (Ry. Mech. E.), v. 91, no. 4. April, 1917, p. 211-212. 280 words, incl. 2 figs. (diagrs., etc.)

LC. (TF1A3,v.91)

Illustrations: [1] Holder for the threading die. [2] Tool holder for turning the body of the screw.

Author describes a tool holder which has been developed for making a one-half inch brass cap screw.

55. The Armstrong Pipe Threading Machine.

(Iron Age), v. lix, April 15, 1897, p. 9. 1 illus.

LC. (T1, I7, v. 49, 1897.)

Short note, describing machine.

56. ATKINSON, ROBERT E.

Standardization of pipe flanges and flanged fittings. (Inst. Mech. E.), no. 2, March-May, 1902, p. 303-371. With discussion. 98 figs. (diagrs., sections, etc.), plates no. 27-40, tables i-xiv. LC. (TJ1I5, 1902.)

Appendix, being portion of a communication sent to the institution by Messrs. Lloyd and Lloyd, Albion Tube Works, Birmingham.

57. ATKINSON, ROBERT E.

Standardization of pipe flanges and flanged fittings. (P. Eng.), v. 25, no. 797, June 6, 1902, p. 533-536; no. 798, June 13, 1902, p. 559-561; no. 799, June 20, 1902, p. 588-591; no 800, June 27, 1902, p. 615-618. 95 outline figs., table i-xiii. LC. (TJ1, P8, v. 25, 1902.)

Paper read before the Institution of Mech. Engineers, London, April 18. 1902.

Tables show standard flanges used by various firms.

Appendix: Being a portion of a communication sent to the institution by Messrs. Lloyd & Lloyd, Albion Tube Works, Birmingham, Eng.

See also: Editorial, ibid., no. 791, April 25, 1902, p. 385-386, and editorial, ibid., v. 25, no. 800, June 27, 1902, p. 601-602.

58. AUBRY, PAUL.

Filetages système français. Par Paul Aubry, Ingénieur des arts et manufactures. (Rev. Tech.), 17e année, t. xvii, no. 9, 10 mai, 1896, incl. 10 figs. (illus., diagrs., etc.) P. O.

59. AUBRY, PAUL.

The French system of screw threads. (Inst. Civ. E.), v. cxxvi, 1896, p. 468-469. ES. 9411. LC. (TA1, I6, v. 126.)

An abstract of a paper in: La Revue Technique, 1896, p. 194.

The original article has 10 figs.

60. BACON, S. NEVIN.

Knurling in the screw machine. (Am. Mach.), v. xxxvi, Feb. 8, 1912, p. 235-236, incl. 13 figs. (sections, etc.) ES. LC. (TJ1, A5, v. 36.)

Article describes knurl-holders for use on the cross-slide of an automatic for various kinds of work, in detail.

61. BACON S. NEVIN.

Knurling tools for screw machines. (Am. Mach.), v. xxxvi, Feb. 22, 1912, p. 295-296, incl. 9 figs. (sections, etc.)

ES. LC. (TJ1, A5, v. 36.)

Author describes a variety of special tools for knurling in the automatic screw machine not commonly seen in regular practice.

See also letter by author in: v. xxxvii, no. 2. July 11, 1912, p. 74. 270 words.

62. BEALE, OSCAR J.

Lead and pitch of a screw—What they are. (Am. Mach.), v. xxx, part 2, July 18, 1907, p. 90-91; 4 figs., (sections). ES. LC. (TJ1, A5, v. 30-2.)

Explains terms used by the firm Brown & Sharpe co.

63. Berechnung von räder-getrieben zum gewindeschneiden. (Zeit. Werkz.), Mai 15, 1912. 3000 words. Illus.

Calculations for wheel motion in screw-cutting.

Contains tables and formulas for determining wheel ratios in screw sizes.

63. Bericht ueber die frage der schluesselweiten zum neuen metrischen gewinde-systems. (Z. O. I. A.), li. Jahrg., no. 43. 27 oct., 1899; p. 601-602; 1,800 words; 1 diagr.; 2 tables; 1 formula.
LC. (TA3, O3, v. 51.)

This is an appendix to a report of the conference held at Zurich in 1898, discussing in particular the width between opposite flat faces of nuts and bolt heads.

"Anhang. Beschreibung des internationalen gewindesystems. S. I.," p. 602.

65. Berrier-Fontaine.

De l'adoption d'une série régulière de filetages pour les vis horologères par M. Berrier-Fontaine, Directeur du génie maritime. (S. E. I. N.), 103e année, 1er sémestre, t. 106, no. 2. février, 1904; p. 154-158.
LC. (T2, S6, v. 106.)

Extrait du Mémorial du génie maritime de décembre, 1903.

66. Bessom, Edward J.

An unusual screw. (Mach.), v. 24, no. 5, Jan., 1918, p. 446. 240 words, incl. 2 figs. (half-tone diagrs.) LC. (TJ1, M21, v. 24.)

66a. Bessom, Edward J.

Bibliography of munition production. (Am. Soc. M. E.), Journal, v. 39, no. 5. May, 1917, p. 386-388. LS. (TJ1, A72, v. 39.)

Contains some material on screw-threads in the manufacture of firearms and ammunition.

67. Bicknell, Thomas.

Thread lead indicator. (Mach.), v. xxiii, July, 1917, p. 1025, incl. 3 figs. (half-tones). ES. Pam. LC. (TJ1, M2, v. 23.)

The same in: Iron Age, v. 100, July 5, 1917, p. 1025. LC.(T1 I 7,v.100) and in: Railway Mech. Engineer, N. Y., v. 91, Aug., 1917, p. 463.

68. Bicycle spoke threading machine. (Iron Age), v. lix, Jan. 21, 1897, p. 9, 1 illus. LC. (T1, I7, v. 59.)

69. Billings, J. Harland.

Errors in measuring thread pitch diameters with wire. (Am. Mach.), v. 47, no. 25, Dec. 20, 1917, p. 1077-1078, incl. 1 fig. (Diagr.)
ES. Pam. ES. LC. (TJ1, A5, v. 47.)

Figure shows "How the error is multiplied."

70. Bolt cutting and nut tapping machine. (Am. Mach.), v. 27, no. 29, June 21, 1904, p. 977, 150 words, 1 half-tone.
LC. (TJ1, A5, v. 27.)

70a. Bode, J. C. P.

Methods of expressing tolerances. (Mach.), v. 25, no. 1, Sept., 1918, p. 85; 480 words.

71. Breech-blocks, (Eng.), v. lxxxvii, Feb. 12, 1909, p. 220-221, 3 figs. (sections). ES. 15330. LC. (TA1, E55, v. 87.)

Deals with the modern form of the screw breech-block.

72. Briggs, Robert.

A uniform system of screw threads. (Frank. I.), v. 79, 1865, p. 111-125, incl. 3 tables, plate iii (fold.), figs. i-v, diagrs., etc.).
ES. 11431.

At head of title: "For the Journal of the Franklin Inst."

72a. BRIGGS, ROBERT.

American practice in warming buildings by steam. Paper 1823. (Inst. Civ. E.), v. lxxi, 1883; p. 95-175, incl. 15 figs., tables i-xiv.

ES. 9357. LC. (TA1, I6, v. 71.)

Appendix, p. 124-138.
Discussion, p. 139-162.
Correspondence, p. 163-175.
"Wrought-iron welded tubes," p. 96, treats on taper screw-threads for tube connections.

73. BRITISH ASSOCIATION SMALL SCREW GAUGE COMMITTEE.

(Mech. Eng.), v. 13, no. 323, April 2, 1904, p. 497-500, 2,000 words, 5 figs., 4 tables. LC. (TJ1, M4, v. 13.)

This is a brief history of the labors of the above committee, and a final report of investigations and results.
The committee consisted of: R. E. Crompton, J. M. Gorham, G. K. Elphinstone, Mark Barr, C. V. Boys, O. P. Clements, and W. A. Price.

74. BROOKER, ARTHUR.

Measurement of screw threads. (Sci. Am. S.), v. lxxxv, no. 2196, Feb. 2, 1918, p. 71. ES. LC. (T1, F52, v. 85.)

From Engineering Supplement, London Times.
This is an abstract of the author's paper read before the Liverpool Engineering Society.

75. BROOKER, ARTHUR.

Screw thread measurement. (Eng.), v. ciii, no. 2666, Feb. 2, 1917, p. 113-116; no. 2667, Feb. 9, 1917, p. 139-141; no. 2668, Feb. 16, p. 165-166. Figs. 1-28, (half-tones, diagrs., sections, etc.), formulas.

ES. LC. (TA1, E55, v. 103.)

Contents: Section i. Introduction.—Section ii. Definitions, p. 113.—Section III. Methods of measurement. 1. Measurement of elements by microscope micrometer, p. 114-116.—2. Diametrical measurements by floating micrometer, p. 139.—3. Optical projection apparatus.—4. Measurement of pitch by mechanical means, p. 165. Section iv. Concluding remarks, p. 165-166.
This paper was read before the Liverpool Engineering Society.
Deals with the Whitworth standard system, and with the methods of measurement.
See also Cambridge Scientific Instrument co., title no. 79.

75a. BROPHY, J. P.

Interchangeability, tolerances and finish. (Am. Mach.), v. 48, no. 4. Jan. 24, 1918, p. 156-157. ES. LC. (TJ1, A5, v. 48.)

Contents.—Interchangeability should be considered.—Inspectors play an important part.—Money expended foolishly.
Mr. Brophy is vice president and general manager, Cleveland Automatic Machine co.
He gives his ideas regarding the requirements along the lines of interchangeability, tolerances and finish.

76. BROWN, E. P.

Screw thread standards. (Mach.), v. 19, no. 5. Jan., 1913, p. 372.

LC. (TJ1, M21, v. 19.)

77. BUCKINGHAM, EARLE.

Accuracy vs. precision, and the gage problem. Letter to editor, by

Earle Buckingham, Captain, Ord. Dept., U. S. R., Gage manager, and G. F. Matteson. (Am. Soc. M. E.) Journal, v. 40, no. 2, Feb., 1918, p. 158-160. ES. LC. (TJ1, A72, v. 40.)

77a. BUCKINGHAM, EARLE.

American industrial progress as revealed by war orders. (Am. Mach.), v. 46, no. 8, Feb. 22, 1917, p. 315-321. ES. LC. (TJ1, A5, v. 46.)

Contents.—Difference between American and European manufacturing development.—The opportunity for close comparison of the two systems.—Elementary principles of manufacturing.—Classes of inchangeable manufacture.—Determining allowance variations.—The inspection service and assembling.—Very little interchangeable work turned out in United States.—A serious mistake at the outset.—Disregard of specifications.—Result of slighting preliminary work.—The handicap of unskilled employees.—Inspection was considered a necessary evil.—The rush for gages and need of gage makers.—''American practice'' must undergo radical changes.

78. BUCKINGHAM, EARLE.

Calculating change-gears for 4-5 mm. pitch. (Mach.), v. 24, Jan., 1918, p. 448, incl. diagrs. LC. (TJ1, M2, v. 24.)

79. [THE CAMBRIDGE SCIENTIFIC INSTRUMENT CO., CAMBRIDGE, ENG.]

Screw thread measurement. Letter to the editor, dated Feb. 19, 1917, by The Cambridge Scientific Instrument Co., (Horace Darwin, Chairman), Cambridge, Eng. (Eng.), v. ciii, no. 2669, Feb. 23, 1917, p. 186. ES. LC.(TA1E55,v.103)

Refers to paper by A. Brooker, which see, and to an instrument for thread measurement constructed by them.

80. CAMMERER, H.

Beitraege zur schraubenberechnung. Vortrag von H. Cammerer. (V. D. I.), band xxxxiv. 2 halbjahr. 11. Aug., 1900, p. 1063-1065, 2,000 words, 8 figs. LC. (TA3, V5, v. 44-2.)

This is a lecture under the title: ''Notes on the computation of screw threads.''

It shows, by the aid of diagrams, the various stresses and formulas for computation, including the influence of torsion.

81. Camming Automatic Screw Machines (Ry. Mach.).

Feb., 1903, p. 185-188, incl. 8 figs. (sections). P.O.

Sub-title: Explanation of principle, and demonstration.

82. CANTELO, WALTER.

Measuring external screw thread diameters. (Am. Mach.), v. xxvi, no. 26, June 25, 1903, p. 904-906. 1200 words. 7 outline figs., 2 tables. LC (TJ1 A5,v.26,1903)

Tables.—i. Constants for measuring U. S. Standard, V, and Whitworth threads. ii. Constants for Acme standard threads.

Author furnishes formulas, etc., so that the standard threads can be compared with the figures given in his table by the use of ordinary micrometer calipers.

83. CARTER, ALFRED E.

Indicator used for cutting internal threads. (Mach.), v. xxiv, May, 1918, p. 790. ES—Pam. LC(TJ1M2,v.24)

84. Cellerier, F.

L'unification des systèmes de filetage. (Tech. M.), Dec., 1910. 6000 words. Illus. E.

Author gives an outline of the status of a movement to standardize the the systems of screw-threads.

84a. Chubb, I. W.

The British 6-in. howitzer. iii. Body and breech mechanism. (Am. Mach.), v. 49, no. 14, Oct. 3, 1918, p. 605-612, incl. figs. no. 65-80 (half-tones, sections, etc.). ES. LC.(TJ1A5,v.49)

''Internal threads,'' p. 612.

''Accumulation of errors,'' p. 612.

85. Chubb, I. W.

Producing British screw gages. (Am. Mach.), v. 46, no. 14. April 5, 1917, p. 593-594, incl. 3 half-tones, 1 table. ES. LC.(TJ1 A5,v.46.)

Illustrations: 1. The V tool. 2. The tool under the microscope. 3. Testing pitch diameter.

Table: Solid threaded plug.

Notes of author on screw gages made by the British firms E. G. Wrighley & co., ltd., Soho, Birmingham, and others, and their methods of manufacture.

86. Clark, J. J.

Finding angle of special screw thread. (Mach.), v. 24, July, 1918, p. 1043. 250 words, incl. 1 diagr. ES.—Pam. LC.(TJ1 M2,v.24)

87. Clements, O. P.

On screw threads used in cycle construction, and for screws subject to vibration. (Engi.), v. xc, Sept. 21, 1900, p. 302. 1200 words, 4 figs. (sections), 1 table ES. 11012 LC.(TA1 E5,v. 90)

Read before Section G, British Association, Sept. 11, 1900.

Treats on the shape of threads.

Figures give sections of B. S. A., British Association, Sellers and Whitworth threads.

88. Clough, Francis W.

United States standard thread tool gage. (Mach.), v. 20, no. 5, Jan., 1914, p. 404. 600 words, incl. 1 ouline cut. ES.—Pam. LC.(TJ1M2,v.20)

89. Coburn, F. G.

Everyday screw thread troubles. (Am. Mach.), v. 36, no. 23, June 6, 1912, p. 908-909. Figs. 1, 2. ES. LC.(TJ1 A5,v.36)

Author is asst. naval constructor, U. S. Navy.

Troubles which have come up in securing satisfactory results with the fitting of threaded parts, and suggestions for remedying the defects.

90. Colburn, George L.

A screw-thread angle-table. (Am. Mach.), v. 27, no. 23, June 9, 1904, p. 758. 500 words, 1 table. LC.(TJ1 A5,v.27)

Table gives the angle of helixes of various pitches and diameters with respect to a line perpendicular to the axis, with explanatory notes.

91. Commission International d'Unification des Filetages.

Réunion à Zurich, 1900. Système international des filetages à base métrique. Overture de clefs. Circulaire de la Commission international

d'unification des filetages, réunion à Zurich (October, 1900). (S. E. I. N.), 100e année, 1er sémestre, t. 101, no. 3, 31 janvier, 1901, p. 129-144. Tables, formulas. LC.(T2S6,v.101,1901)

Signed: Le sécretaire, A. Jegher.

''Règles du système international de filetages. S. I.,'' p. 130-132.

''Procès-verbal de la Conférence internationale réunie à Zurich le 20 octobre, 1900, pour la fixation des ouvertures de clés, p. 133-134.

''Programme de la conférence pour la fixation des ouvrages de clés du système de filetage international, S. I.''

A discussion of the S. I. proposed in the conference of 1898 at Zurich, and of subsequent questions relating to dimensions of keys and wrenches.

91a. Cook, Charles A.

Designation of threads. Letter by C. A. Cook, Detroit, Mich. (Mach.), v. 25, no. 1, Sept., 1918, p. 62-63. LC.(TJ1M21,v.25)

92. Coyne, James F.

Measuring and testing taps and screws. (Am. Mach.), v. 47, no. 19, p. 824. 220 words, incl. 2 figs. (diagr., chart).

ES.—Pam. LC.(TJ1A5,v.47)

Illustrations: Fig. 1. Gage for screws. Fig. 2. Tolerance chart for screws.

93. [Crompton, R. E. B.]

Screw gages. (Sci. Am. S.), v. lxxxiv, no. 2186, Nov. 24, 1917, p. 333. 780 words. ES. LC.(T1F5,v.84)

From Engineering Supplement of London Times.

Abstract of some notes on screw gages, presented by Col. Crompton to the Institution of Automobile Engineers, London.

94. Crompton, Colonel R. E.

Screws and gauges. (Horseless A.), v. 39, no. 5, March 1, 1917, engineering section, p. 9-10. LC.(TL1 H81,v.39)

Sub-title: Definitions of terms used in accurate screw work.—Number and types of gauges required.—Difficulty in making the gauges.

''Effect of excessive tolerance on strength,'' p. 10.

''Gauging nuts,'' p. 10.

Article reviews report of the National Physical Laboratory made in Sept., 1916, on screw gauges, and on paper read by Col. Crompton before the Institution of Automobile Engineers, London.

Abstract of above in: (Am. Soc. M. E.), v. 39, no. 4. April, 1917, p. 351. ES. LC. (TJ1A72, v. 39.)

95. Cutting Lead Screws with Bolt Dies.

(Mach.), v. 23, Jan., 1917, p. 404. 800 words.

ES.—Pam. LC.(TJ1M2,v.23)

96. Cutting Multiple Threads.

(Mach.), v. 24, no 1, Sept., 1917, p. 56. 330 words. LC.(TJ1M21,v.24)

97. Cutting Screw Threads. (Editorial.)

(Mach.), v. 24, no. 2, Oct., 1917, p. 116. LC.(TJ1M21,v.24)

98. Davis, W. H.

Cutting multiple thread screw in the lathe. (Mech. W.), v. li, no. 1307, Jan. 19, 1912, p. 26-27. 1500 words, incl. 5 figs. (sections).

LC.(TJ1M55,v.51)

99. De Leeuw, A. L.

Cutting square threaded screws. (Am. Mach.), v. xxiv, part ii, no. 24, Oct. 17, 1901, p. 1160-1162. 5 outline figs. LC.(TJ1A5,v.24-2)

Illustrations: A square thread, its tool and its nut.

100. Dimensions of standard metric machine screws.

(Am. Mach.), v. 47, no. 10, Sept. 6, 1917, p. 422, incl. formulas, chart; no. 16, Oct. 18, 1917, p. 694, incl. diagrs., formulas.

ES. LC.(TJ1A5,v.47)

Extract from "Zeitschrift für instrumentenkunde." Translated.

Illustrations: Forms and dimensions of metric machine screws.

101. Donaldson, H. F.

Interchangeability and methods of securing it in screw threads. Lecture by H. F. Donaldson. (Inst. Mech. E.), parts 1-2, 1909, p. 253-292. 26 figs. LC.(TJ1 I5,pts.1-2,1909)

102. Donaldson, H. F.

Interchangeability and methods of securing it in screw threads. (Eng.), v. cvii, Feb. 12, 1909, p. 170-171; Feb. 19, 1909, p. 201-202. 15 figs. half-tones, diagrs., sections, etc.). ES. 15326 LC.(TA1E5,v.107)

Lecture at graduates' meeting, Feb. 8, 1909, of the Inst. of Mech. Engineers, London.

The same article in: (Engi.), v. 87, Feb. 12, 1909, p. 212-213; Feb. 19, 1909, p. 261-286. 44 figs. (diagrs., sections, etc.)

ES. 15330. LC.(TA1,E55,v.87)

103. Doorakkers, G.

The manufacture of hardened thread gauges. i. (Engi.), v. cxxiv, no. 3222, Sept. 28, 1917, p. 263-265. 2000 words. Figs. 1-10B, formulas.

ES. LC.(TA1,E5,v.124)

Deals with a way of checking mechanically, which compares favorably with the optical way.

104. Ehrman, Edwin H.

Screw thread situation in Great Britain and America. (Soc. Autom. E.), Journal, v. iii, no. 2, Aug., 1918, p. 122-131. Figs. 1-8 (diagrs., sections, etc.), formulas. ES. LC.(TL1 A6,v.3)

Contents.—Profiles not arbitrary.—Comparisons of thread profile.—Tolerance on the roots.—Ease of production.—Influence in manufacturing.—Use of fine pitches.—Disposition of limits.—Tolerances and allowances.—Effect of lead (or pitch) errors.—Effect of error of angle.—Application of gages.—Gale tolerances and limits.—Author's conclusion.

Author is secretary and factory manaegr of the Chicago Screw co.

105. Ehrman, Edwin H.

Screws. (Ry. Mach.), Sept., 1903, p. 565-567, incl. figs. 1-4 (diagrs.).

Patent Off. Lib.

Extract from article in "The Michigan Technic."

Shows U. S. standard.—V standard.—Whitworth standard.—International standard.—British Association standard.—Acme standard threads.

106. Eisler, Charles.

Cutting double threads in one operation. (Am. Mach.), v. 48, no. 19, May 9, 1918, p. 803-804. 110 words. 2 outline cuts.

ES. LC.(TJ1 A6,v.48)

Illustrations: Figs. 1, 2. Tools for outside and inside threads.

Describes tool used by author for some time for cutting double threads.

107. The Elimination of the V-Thread.

(Iron Age), v. lxxxiii, no. 8, Feb. 25, 1909, p. 644-645. 1800 words. 1 table. LC.(T 1 I 7,v.83)

Sub-title: Tap and die makers adopt the U. S. standard.

Contents.—The V-thread standard no standard.—Difference in diameter.—Impracticability of the V-standard.—Two possible courses.—Recognition of the advantages of the U. S. standard.

108. Ellis, M. E.

Adaptability of universal drill jigs. (Am. Mach.), v. xxxvii, no. 18, Oct. 31, 1912, p. 729-730, incl. 8 figs (half-tones and sections). ES. LC.(TJ1 A5,v.37)

On the use of universal jigs in the production of accurate and interchangeable work. Types of jigs that have proved satisfactory in this respect, and their varied uses.

109. Ellis, M. E.

Standardization of special tools. (Am. Mach.), v. xxx, pt. i, June 6, 1907, p. 800-802, incl. 14 figs. (sections, half-tones, charts, etc.) 1 table. ES. 9675 LC.(TJ1A5,v.30-1)

Fig. 4. Collar-head jig screws.—5. Winged jib screws.—6. Square-head jig screws.—7. Headless jig screws.—8. Nurled-head jig screws.—9. Same as 8.—10. Locking jig screws.

110. Elmer, Arthur D.

Merits of Cadillac form of thread. (Am. Mach.), v. xxxiv, Feb. 2, 1911, p. 211-214. 2500 words. 5 figs., 3 tables. LC.(TJ1 A5,v.34,1911)

This article explains the form of thread adopted by the Cadillac Car Co., and author compares it with other forms, and its advantage over them.

111. Emery, A. H., Jr.

Cutting testing machine screws. (Am. Mach.), v. xxxvii, no. 8, Aug. 29, 1912, p. 335-336, incl. 4 figs. (half-tones), 1 table. ES. LC.(TJ1 A5,v.37)

"These screws are 12-in. in diameter by 50 ft. long, with an Acme thread of 1½ in. pitch cut for a distance of 30 ft. from one end."

"The errors in the cutting of the thread were measured by means of a special gage and corrected by a novel fixture applied directly to the thread."

111a. Erdman, A. W.

Limits and tolerances for the manufacture of munitions. (Am. Soc. M. E.), Journal, v. 39, no. 5, May, 1917, p. 382-384. ES. LC.(TJ1 A72,v.39)

This is an abstract of a paper for presentation at the spring meeting, Cincinnati, O., May 21-24, 1917, of the American Society of Mechanical Engineers.

See also fuller entry under no. 111b.

Also in: (Iron Age), v. 99. May 10, 1917, p. 1137-1138; (Iron Trade Review, Cleveland, O.), v. 60, May 24, 1917, p. 1130, the latter being condensed.

111b. [Erdman, A. W.]

Limits and tolerances for the manufacture of munitions. (Am. Mach.), v. 47, no. 2, July 12, 1917, p. 73-74. ES. LC.(TJ1A5,v.47)

Contents.—Relation of tolerances to weight.—Thread tolerances—Individual judgment of inspectors—Machine-tool limitations—Maximum production the real aim of any revisions.

From a paper read by Mr. Erdman, of the General Electric Co., at the spring meeting of the A. S. M. E., Cincinnati, O., May 21-24, 1917. . . . "The purpose of this paper is to direct attention to some of the practical aspects of the question of limits and tolerances, as customarily applied to the manufacture of munitions, rather than to attempt to establish standards of high technical value in assigning definite limits to the several classes of dimensions involved." (Quoted from introductory remarks.)

112. Errors in and Limits of Workmanship.
(Am. Mach.), v. xxx, pt. i, Jan. 3, 1907, p. 12-14, incl. 3 figs. (diagrs.), tables 1-2. ES. 8675 LC.(TJ1A5,v.30)

Two comprehensive reports of the British Engineering Standards Committee.

Contents.—Basis of work—Differences between British and American practice—Graphic representation of the measurement.—

Fig. 1. Average errors—Shafts. 2. Average errors—Holes. 3. British standard tolerances and allowances for running fits.

113. Filetages à base métrique (système internationale), 1901.
(Génie C.), v. xxxviii, p. 333. LC. (TA2 G3,v.38)

114. Filetages à la Fraise.
Génie C.), 22e annèe, v. xl, no. 3, 16 novembre, 1901, p. 49. 420 words, 1 illus., 1 diagr. LC.(TA2 G3,v.40)

Illustration: Machine pour le filetage à la fraise.

From Am. Machinist, Sept. 7, 1901.

115. Fine screw Thread Standards. (Editorial.)
(Mach.), v. 19, no. 1, Sept., 1912, p. 16. TJ1M21,v.19)

Relates to the efforts made to establish a uniform standard system of screw threads in this country.

Fontaine Berrier. See Berrier-Fontaine.

116. Fosnot, L. P.
Adjustable female thread gage. (Am. Mach.), v. 47, no. 8, Aug. 23, 1917, p. 339, incl. 2 figs. (sections), 2 tables . 40 words.
ES. LC.(TJ1 A5,v.47)

Figures show adjustable female thread gage.

117. France. Commission de Filetages.
Compte rendu de la séance de la commission en date du 7 mars 1916. Unification des filetages sur tubes. (S. E. I. N.), 115e année, 1er sémestre, t. 125, no. 3, mai-juin, 1916, p. [466]-[467]. 1 table.
LC. (T2 S6,v.125)

Table: Dimensions proposées pour l'unification universelle des filetages sur tubes. Filetages cylindriques—Filetages coniques au 1-16. (Tableau simplifié proposé par la Commission des filetages de la Société d'encouragement.)

Note.—Cette commission est actuellement composé de : M.le général Sebert, président, MM. Carpentier, Toulon, Lieut.-Colonel Paul Renard, Marre et Arnould, membres du Comité des arts èconomiques, MM. Sauvage, Terré, Brocq et Massoǹ, membres du Comité des arts mécaniques.

118. [France] Commission des Filetages.
Congrès des Associations internationales, Bruxelles, 1910. Rapport sur l'unification des systèmes de filetage presénté au Congrès mondial de

l'Exposition de Bruxelles au nom de la Société d'encouragement pour l'indutrie nationale française, par M. le général Sebert, délégué. (S. E. I. N.), 109e année, 1re sémestre, t. 113, avril, 1910, p. 503-507. 2000 words. LC.(T2S6,v.113)

Report by General H. Sebert of the Screw-thread commission, on a proposition to standardize screw threads. The project was presented at a conference held during an exposition at Brussels under the auspices of the French society for the encouragement of national industries.

119. France. Commission des Filetages.
Rapport fait par M. Gustave Richard, au nom de la Commission des filetages, sur l'unification des filetages. (S. E. I. N.), 92e année, 4e série, t. viii, avril, 1893, p. 173-178. Dated 10 mars, 1893. LC.(T2S6.v.92,1893)

120. [France. Commission de Filetages.]
L'unification des filetages à l'étranger. Compte rendu de la séance du Comité d'action suisse pour l'unification des filetages des jauges tenue à Zurich, le 20 nov., 1897 (S. E. I. N.), 96e année, 5e série, t. iii, no. 2, février, 1889, p. 203-249. LC. (T2, S6, v. 3, 1897.)

121. [France. Compagne des Chemins de fer l'Ouest.]
Application des règles du système française de filetage pour les vis mécaniques au matérial de la compagnie de l'ouest. M. Clerault, Ingenieur en chef. (S. E. I. N.), 97e année, 5e série, t. iii, janvier, 1898, p. 85-90. Fig. no. 6 (diagr.), 2 tables. LC. (T2, S6, v. 3, 1898.)

Tables: i. Boulons-types de 6 mm. à 56 mm. de diamétre. ii. Ecrous, goupilles, etc.

122. French Screw Gauges. (Engi.), v. cxxii, no. 3168, Sept. 15, 1916, p. 234. 300 words. 2 figs. ES. LC. (TA1, E5, v. 122.)

Relates to ''instructions' by the French Minister for War, sent out to manufacturers in 1913. Gauge was revised by M. Marre.

Figues show the gauge proper, the ''crocodile.''

123. French Standard Screw Threads. (Eng.), v. lix, April 26, 1895, p. 546. 1440 words. ES. 10982. LC. (TA1, E55, v. 59.)

Article discusses the system proposed by the French Minister of the Marine.

124. Gaging Systems for Screws and Taps. (Mach.), v. 23. July, 1917, p. 967-968, incl. 9 outline figs. ES. Pam. LC. (TJ1, M2, v. 23.)

Treats on devices for measuring variations in lead and diameter.

125. Gardner, Guy H.
Gage for U. S. S. thread tools. (Mach.), v. 20, no. 8. April, 1914, p. 681-682, incl. 2 diagrs. ES. Pam. LC. (TJ1M2, v. 20.)

126 Gardner, Guy H.
Removing rusty screws. (Mach.), v. 23. March, 1917, p. 622-623, incl. diagrs., 1 chart. ES. Pam. LC. (TJ1M2, v. 23.)

127. Gardner, Guy H.
Screw compensation for shrinkage in hardening. (Mach.), v. 20, no. 6. Feb., 1914, p. 499. ES.—Pam. LC. (TJ1M2, v. 20.)

Below this article: "[Reply by] D. Tappan, incl. 1 diagr., showing lathe carriage with special lead-screw nut to decrease pitch of thread being cut.

128. GARDNER, GUY H.

Thread measuring tool. (Mach.), v. 21, no. 3. Nov., 1914, p. 226, incl. 2 diagrs. ES.—Pam. LC. (TJ1M2, v. 21.)

129. GAY, E.

Montages pour l'usinage de pièces détachées des moteurs d'automobiles. (Tech. M.), v. v, 2e sémestre, 1912, p. 327-332, incl. 15 figs. (half-tones, diagrs., etc.) ES.—E.

"Filetage sur l'extrémité d'un tuyau collecteur," p. 330.

130. GILL, JOHN L., JR.

Screw threads. By John L. Gill, jr., Philadelphia, Pa. (Frank. I.), v. 125, 1888, p. 186-199. 4 plates, (figs., diagr.), 2 fold. plates, (tables.) ES.

Read at stated meeting, Nov. 16, 1887.

Author proposes a new system for which he claims an increase of strength of 17 per cent. over the Sellers system. He also states the objections to the Sellers system.

131. GOVERNMENT COMMISSION TO STANDARDIZE SCREW THREADS. (Soc. Autom. E.), Journal, v. 2, no. 6, June, 1918, p. 449. LC. (TL1, S5. v. 2.)

Relates to bill no. 10852 passed May 8, 1918, by the House of Representatives, as reported by the House Committee on coinage, weights and measures.

132. HALL THREAD-MILLING FIXTURE. (Am. Mach.), v. 48, no. 15. April 11, 1918, p. 638. 150 words, 1 half-tone. ES. LC. (TJ1, A5, v. 48.)

Illustration shows the fixture made and placed on the market by the Hall Gas Engine Co., inc., Bridesburg, Philadelphia, Pa. It is used for cutting either internal or external threads of any form or pitch and either straight or taper.

133. HAMILTON, DOUGLAS THOMAS.

The "Acme" multiple spindle automatic screw machine. i. (Mach.), v. 19, no. 4. Dec., 1912, p. [243]-249; ii., no. 5. Jan., 1913, p. 335-341, incl. 31 figs. (half-tones, diagrs., charts, etc.) tables i-ix. (TJ1M21, v. 19.)

134. HAMILTON, DOUGLAS THOMAS.

Gaging and inspecting threads. i. (Mach.), v. 23, no. 6. Feb., 1917, p. 477-486. Front., 15 figs. (half-tones, sections, etc.), tables no. i-ix; the same, ii. (Mach.), v. 23, no. 7. March, 1917, p. 581-586. 7,000 words. Figs. 16-34 (half-tones, sections, etc.) ES.—Pam. LC. (TJ1, M21, v. 23.)

Table i. British standard Whitworth threads.—Tolerances for bolts.—ii. British standard Whitworth screw threads. iii. Allowances to compensate for errors in pitch of British standard Whitworth screw-threads. iv. Tolerances on included angle of screw threads. (The Engineering Standards Committee). v. Tolerances on pitch diameters of U. S. Standard screws, taps and gages (loose fit tolerances). vi. Tolerances of pitch diameters of U. S. Standard screws, (taps and gages close fit tolerances). vii. Propositions for Briggs standard reference pipe ring gages (Cadillac Motor Car Co.). viii. Propositions for Briggs standard reference pipe plug gages (Cadillac Motor Co.). ix. Dimensions of ball points used in measuring screw threads.

135. HAMILTON, DOUGLAS THOMAS.

Gridley multiple-spindle automatic screw machines. i. (Mach.), v. 23. June, 1917, p. 859-863; ii., July, 1917, p. 973-979, 4,500 words, incl. 33 figs. (half-tones, diagrs., sections, etc.), tables 1-6.

ES.—Pam. LC. (TJ1M2, v. 23.)

Author treats on design, construction, operation and tool equipment.

136. HAMILTON, DOUGLAS THOMAS.

Operating the Gridley multiple-spindle screw machine. (Mach.), v. 24. May, 1918, p. 839-844. 3,500 words, incl. 14 figs. (half-tones, 5 sections, etc.) ES.—Pam. LC. (TJ1M2, v. 24.)

Contains complete instructions for tooling, setting up, and operating the above machine.

137. HAMILTON, DOUGLAS THOMAS.

Screw machine tool equipment. i. (Mach.), v. 24, no. 2. Oct., 1917, p. 118-122, incl. 15 figs. (half-tones, diagrs., etc.); ii, no. 4, Dec., 1917, p. 331-334, incl. figs. 16-27; iii. no. 5. Jan., 1918, p. 436-438, incl. figs. 28-37 (half-tones, diagrs., etc.) LC. (TJ1M21, v. 24.)

Sub-title.—Tool equipment and attachments for the Gridley multiple-spindle automatic screw machine.

138. HAMM, WALTER C.

Standard screws. (Monthly C. R.), no. 293, Feb., 1905, p. 75-76. LC. (HC1R2, 1905.)

Report dated Jan. 4, 1905, by W. C. Hamm, U. S. Consul at Hull, Eng., on Results of labors of a Committee of the British War Office, and on application of standards at the National Physical Laboratory at Bushy House, London.

139. HAMMOND, EDWARD K.

Making precision screws for scientific instruments. (Mach.), v. 23. June, 1917, p. 849-854. 4,000 words, incl. 12 figs. (7 half-tones, diagrs., etc.). ES.—Pam. LC. (TJ1M2, v. 23.)

Author describes methods for cutting and testing precision screws for astronomical and other scientific instruments. Includes instructions for two forms of interferometers, one of which provides means for measuring to one-millionth inch.

140. HARRIS LEAD AND ANGLE TESTING DEVICE FOR THREAD GAGES. (Mach.), v. 24, no. 2. Oct., 1917, p. 178-179, incl. 4 figs. (half-tones, diagrs.) LC. (TJ1M21, v. 24.)

141. [HARTNESS, JAMES]

Scheme of gaging for screwed parts. Letter to editor, by James Hartness, Springfield, Vt. (Am. Soc. M. E.), Journal, v. 40, no. 2. Feb., 1918, p. 157-158, incl. 1 fig. (sections, etc.) ES. LC. (TJ1A72, v. 40.)

Author deals with the betterment of the lead of die-cut screws.

142. HARTNESS, JAMES.

A screw die for the turret lathe. By James Hartness, Springfield, Vt. Paper no. dccliii. (Am. Soc. M. E.), v. xix, 1898, p. 77-80. Figs. no. 19-25 (sections, etc.) LC. (TJ1, A7, v. 19.)

143. HARTNESS, JAMES.

A stay bolt threading device. Paper no. dccliv. (Am. Soc. M. E.), v. xix, 1898, p. 81-82, incl. fig. no. 26, (sections.) LC. (TJ1, A7, v. 19.)

Fig. 26 shows the use of the automatic die described in paper dccliii, under title: A screw die for the turret lathe.

144. HESS, HENRY.

The S. I. Standard metric thread in continental Europe. (Am. Mach.), v. xxiii, no. 18, May 3, 1900, column 422-38, to 39-423. 1,200 words. 2 figs., (diagrs.) LC. (TJ1, A5, v. 23, 1900.)

Fig. 1. Standard metric thread enlarged. Fig. 2. Relation of pitch to diameter.—Metric and U. S. Standard threads.

Author discusses the efforts made for a uniform system of screw threads, and reviews the "Système internationale" which has been adopted in the continental Europe which must be considered by the Manufacturers of America when seeking foreign trade.

145. HINKEL, ROY A.

Time studies in screw-machine practice. (Am. Mach.), v. 48, no. 12. March 21, 1918, p. 507-508, incl. 2 charts. ES. LC. (TJ1, A5, v. 48.)

Chart 1. A time-study sheet.—Chart 2. A chart on screw machine practice.

146. HIRSCHMANN, W. F.

Utilizing discarded geometric chasers. (Am. Mach.), v. 47, no. 24, Dec. 13, 1917, p. 1055. 250 words, incl. 3 figs.

ES.—Pam. LC. (TJ1, A5, v. 47.)

Illustrations: Figs. 1-3. Holder for geometric chasers, facing and centering tool and chamfering tool.

These figs. show how discarded "geometric" chasers can be utilized. . .

147. ILER, W. T. JR.

Master Whitworth thread gages. (Mach.), v. 24, no. 1. Sept.., 1917, p. 51-52, incl. 5 figs., 1 table. LC. (TJ1M21, v. 24.)

148. INSPECTION OF SCREW GAGES FOR MUNITIONS OF WAR. (Mach.), v. 24, no. 5. Jan., 191, p. 452-456, incl. 3 figs. (half-tones), table 1-3.

LC. (TJ1M21, v. 24.)

Sub-title: Measurement of pitch and of full, effective and core diameters.

149. INTERNATIONAL SCREW THREADS. (Autom. Ind.), v. xxxvii, no. 26, Dec. 27, 1917, p. 1131. LC. (TL1, A6, v. 37-2.)

Sub-title: London conference Jan., 1918, aims at Anglo-American standardization—under government instigation.

150. INTERNATIONALES GEWINDESYSTEM AUF METRISCHER GRUNDLAGE. (Z. O. I. A.), liii. Jahrg., no. 15. 12. April, 1901, p. 273-274. 800 words. 1 diagr., 1 table. LC. (TA3, O3, v. 53, 1901.)

Table: Skala der normaldurchmesser und der zugehoerigen ganghoehen und schluesselweiten.

Describes briefly, the International metric screw-thread system adopted by the Society of German Engineers, the Society for the Encouragement of national industry, (France), and the Society of Swiss Machine Industry, at Zuerich, Oct., 1900.

151. INTERNATIONAL SYSTEM OF SCREW-THREADS ON A METRICAL BASIS. (Inst. Civ. E.), v. cxxxix, 1899, p. 443. ES. 9424. LC. (TA1, I6, v. 139.)

Abstract of an article in Schweizerische bauzeitung, 1899, p. 54.

152. JACOBS, F. B.

The making of bushing for drill jigs. (Mach.), v. 19, no. 1. Sept., 1912, p. 12-15, incl. 14 figs. (half-tones, diagrs., etc.) LC. (TJ1M21, v. 19.)

Sub-title: Proportions of bushings, materials used, turning, hardening, grinding and lapping operations.

153. JEFFCOTT, H. H.

Notes on screw threads. By H. H. Jeffcott, of the National Physical Laboratory, Teddington. (Inst. Mech. E.), parts 3-4, Dec., 1907, p. 1067. incl. diagrs., formulae, 2 tables. LC. (TJ1, 15, pts. 3-4, 1907.)

154. JEFFCOTT, H. H.

Notes on screw threads. By H. H. Jeffcott, B. A., B. A. I., Principal assistant in the Physics dept. (N. Phys. L.) v. v, 1909, p. 215-250, incl. figs. 1-17 (diagrs., etc.), tables, i, ii, and formulae. P.O.

[Reprinted from the Minutes of proceedings of the Institution of Mech. Engineers, 1907, ii.]

155. JIGS FOR SMALL TOLERANCES. (P. Eng.), v. 58, no. 1636, July 4, 1918, p. 3-4. ES. LC. (TJ1, P8, v. 58.)

Contains also cross-sections and formulas.

156. JONES, FRANLIN D.

General thread cutting practice in the lathe. (Mach.), v. 24, no. 7. March, 1918, p. 634-639, incl. 9 figs. (half-tones, diagrs.), 1 table. ES.—Pam. LC. (TJ1M21, v. 24.)

Sub-title: Important points on cutting single, multiple and tapering threads by means of single-point tools and chasers.

157. JONES, FRANKLIN D.

Projection method of testing screw threads. (Mach.), v. xxiv, April, 1918, p. 735-738, incl. 8 figs. (half-tones, outline cuts). ES.—Pam. LC. (TJ1M2, v. 24.)

Arrangement and use of projection apparatus as applied to inspection of thread gages for munitions manufacture.

158. JONES, FRANKLIN D.

Screw thread cutting with dies. (Mach.), v. 24. Oct., 1917, p. [97]-115, 44 figs. (half-tones, sections, etc.), 3 tables. LC. (TJ1M21, v. 24.)

Sub-title: Design, operation, and application of various classes of standard and special tools, machines and attachments used in producing screw threads.

159. JONES, FRANKLIN D.

Thread-cutting attachments. (Mach.), v. 24. Feb., 1918, p. 524-531. 7000 words, incl. 17 figs. (6 half-tones, 11 diagrs., sections, etc.). ES.—Pam. LC. (TJ1M2, v.24)

Deals with standard and special mechanisms and attachments for engine lathes, turret lathes, drilling and boring machines.

160. JONES, FRANKLIN D.

Thread milling. (Mach.), v. 24. Jan., 1918, p. 413-428, incl. illus., diagrs. LC. (TJ1M2, v.24)

161. JONES, FRANKLIN D.

Thread rolling. (Mach.), v. xxiv, April, 1918, p. 690-696; May, 1918, p. 803-809, incl. 27 figs. (half-tones, sections, etc.). ES.—Pam. LC. (TJ1M2, v.24)

Different methods of forming screw threads by rolling.

162. KARTSHER, HARRY S.

Finding effective bearing area of Acme screw threads. (Mach.), v. 24, no. 5. Jan., 1918, p. 440, incl. 1 fig. (diagrs.), 1 table, formulas. LC. (TJ1M21, v.24)

163. KING, WILLIAM RICE

Experiments with bolts and screw threads. By Major W. R. King, U. S. Engineers, Chattanooga, Tenn. (Am. I. M. E.), v. xiv, June, 1885, p. 90-98. 5 outline figs. LC. (TN1 A5, 1885)

Papers of the xliid (Chattanooga) meeting, May, 1885.

"Experiments with screw-threads and nuts," p. 93-96.—"Mean results," p. 96-98.

The author's aim was to determine the advantage of increasing the number of threads. The results show 20 per cent increase of static strength and 3 or 4 times strength to resist impact, by doubling the number of threads to the inch.

This article was reprinted incl. figs., in: Engineering News, v. xiii, Oct. 17, 1885, p. 243-244, and an abstract of the same appeared in: Scientific American v. liii, no. 16, Oct. 17, 1885, p. 224.

164. KONINKLIJK INSTITUUT VAN INGENIEURS. Vakafdeeling voor werktuig en scheepsbouw. Unification des filetages sur tubes. (S. E. I. N.), 99e, année, 5e série, t. v., 28 février, 1900, p. 278-283. 1000 words. 4 tables (questionnaire). LC.(T2,S6,v.5,1900)

This is a questionnaire sent out by the Section of Machinery and Naval Construction of the Royal Institute of Engineers of the Netherlands, providing blank forms for replies. United action in order to secure a uniform standard is urged, by the secretary of the commission, Mr. B. M. Gratama.

165. LEA THREAD LEAD TESTER. (Mach.), v. 24, June, 1918, p. 949-950, incl. 4 half-tones. ES.—Pam. LC.(TJ1 M2,v.24)

166. LEE, ERIC.

Handy gage for setting up threading tools. Letter to Editor. (Mach.), v. 24, no. 2. Oct., 1917, p. 155-156. 210 words, incl. 1 fig. LC.(TJ1M21,v.24)

167. LEE, ERIC.

Spring threading tool Letter to editor. (Mach.), v. 24, no. 3. Nov., 1917, p. 248, 330 words, incl. 1 fig. LC.(TJ1M21,v.24)

168. LINDGREN, J. E.

Grinding and lapping threads. (Mach.), v. 24, July, 1918, p. 1023-1024, incl. 5 figs. (sections, etc.)

Sub-title: Attachments, fixtures, and laps used for producing accurate threads. ES.—Pam. LC. (TJ1, M2, v. 24.)

169. LONGWORTH, G. H.

Dividing the pitch of double and multiple threaded screws. (Mech. W.), v. xlix, o. 1265. March 31, 1911, p. 146. 1800 words. 4 figs. LC.(TJ1M55,v.49,1911)

Gives a description of the various methods employed.

170. THE LOWENHERZ THREAD.

(Mach.), v. xxiv, May, 1918, p. 837, incl. 1 diagr., 1 table, formulas. ES.—Pam. LC.(TJ1 M2,v.24,1918)

171. LUCAS, J. A.

French gages for sheets, wire and screw threads. (Am. Mach.), v. 47, no. 10, Sept. 6, 1917, p. 424-425, incl. 2 figs. (sectional views), tables i-xi, and formulas. ES. LC.(TJ1 A5,v.47)

172. MACGOWAN, F. A.

Time studies on automatic screw-machine products. (Am. Mach.), v. 48, no. 16, April 18, 1918, p. 676, incl. 3 charts. ES. LC.(TJ1A5,v.48)

173. MCINTYRE, JAMES.

Measuring threaded work. (Mach.), v. 22. July, 1916, p. 982. 500 words, incl. 2 outline cuts. ES.—Jam. LC.(TJ1M2,v.22)

On methods found useful by author in measuring the diameter of threaded work.

174. MACINTYRE, J. R.

Production of accurate thread gages. (Mach.), v. 24, no. 1. Sept., 1917, p. 31-32, incl. 5 figs. LC.(TJ1M21,v.24)

Sub-title: Methods used in making thread-cutting and radius-forming tools and angle-grinding fixture.

175. MARRE, CHARLES.

Exécution pratique des vis à filet triangulaire, par M. Marre, Ingénieur de la maison Bariquand et Marre. (S. E. I. N.), 92e année, 4e série, t. viii, 1893, p. 243-251, incl. 3 figs. (diagrs.). LC.(T2S6,v.92,1893)

Contents. 1. Une série unique pour les pas des vis à métaux dans un meme pays est à désirer. 2. Machines-outils et outillage employés á notre époque. 3. L'Interchangeabilité des vis dépend des types de vérification. 4. Les types de vérification interchangeables dépendent de la constante des outils simples. 5. Données d'exécution. 6. Déformation des angles par suite de l'inclinaison des outils sur les machines pour obtenir la coupe. 7. Outils ordinaires généralement employés. 8. Outil de précision à angle constant. 10. [i. e.] 9. Série des pas Bariquand.

176. MARRE, CHARLES.

Rapport sur l'unification internationale des pas de vis dans les filetages sur les tubes et tuyaux des conduites et canalisations pour les fluides, présenté par M. Marre à la Commission des filetages de la Société d'encouragement. (S. E. I. N.), 115e année, ler sémestre, t. 125, no. 3, mai-juin, 1916, p. 468-475, incl. 1 profile, 2 sections, 1 table. LC. (T2 S6,v.125)

Signed: Chas. Marre. . .

At head: "Annexe de la séance du 7 mars, 1916."

Fig. 1. Filetage cylindrique. Fig. 2. Filetage conique. Fig. 3. Profil du filet.

Table: Dimensions proposées pour l'unification universelle des filetages sur tubes. . . .

177. MARRE, CHARLES.

Standard screw threads for pipes. (Inst. Civ. E.), v. cciii, 1916-1917, p. 432. 100 words. ES. LC.(TA1 I 6,v.203)

Abstract of paper dealing with the standard screw threads adopted by a commission of the Society of Encouragement of National Industry, Paris.

178. MARRE, CHARLES.

Sur les instruments vérificateurs des filetages, système française (S. F.), par M. Marre, Ingénieur mécanicien. (S. E. I. N.), 97e année, 5e série, t. iii, janvier, 1898, p. 77-83. 4 outline figs. LC.(T2 S6,v.3,1898)

Author describes the system of gauges used on the metric, French screw thread system.

179. MARTENS, A.

Einfluss der gewindeform auf die festigkeit der schraubenbolzen. (V. D. I.), band xxxix, no. 17. 27. April, 1895, p. 505-508. 13 outline figs., tables i-vii. LC. (TA3 V5,v.39-1,1895)

Title: Influence of the shape of the thread on the strength of the bolt.

Relates to a number of tests made of the tensile strength of bolts provided with different kinds of threads.

180. MASTER CAR BUILDERS' ASSOCIATION, Committee on Screw-Heads, Bolt-Heads and Nuts.

Report of committee. (Hist. E. R.), p. 80-82, incl. 1 table. PO.

Committee: V. D. Perry, Hartford, Prov., & Fishkill Railroad; Geo. Hacket, Central R.R. of New Jersey; R. Hitchcock, Conn. River Railroad.

"Standard for screw-threads, bolt heads and nuts, adopted by the United Am. Railway Master Car Builders' Assoc'n., in convention, at Richmond, Va., June 15, 1871," p. 82.

181. MASTER CAR BUILDERS' ASSOCIATION.

Committee to investigate and report on the present construction of screws and nuts used on cars . . . (Master C. B. A.), 13th convention, 1879, p. 70-73, incl. 2 tables. PO.

Submitted by John Orton, C. S. R.

Discussion, p. 76-83.

Standard for screw-threads, bolt-heads, and nuts adopted by the M. C. B. A., in convention, at Richmond, Va., June 15, 1871.

Table, p. 121.

182. [MASTER CAR BUILDERS' ASSOCIATION.]

Screw threads. (Master C. B. A.), report of proceedings of an adjourned meeting . . . held at Niagara Falls, 1882, p. 75-76. 1 fold. table. PO.

Fold. table: "Proportions for Sellers' standard screw-threads, nuts and bolts," facing page 75.

183. [MASTER CAR BUILDERS' ASSOCIATION.]

Standard screw threads on cars. (Master C. B. A.), 17th annual convention, 1882, p. 200-223, incl. 6 figs., 2 tables. PO.

Signed: M. N. Forney.

"Standard for screw-threads, bolt-heads and nuts adopted by the Master Car Builders' Assoc'n., in convention, at Richmond, Va., June 15, 1871," p. 239.

184. [MASTER CAR BUILDERS' ASSOCIATION.]

Screw threads, bolt heads and nuts. Standard. (Master C. B. A.), v. 33, 1899, p. 425-428. Figs., diagrs., tables. ES. 25103

185. [MASTER CAR BUILDERS' ASSOCIATION.]

Screw-threads, bolts and nuts. Standard. (Master C. B. A.), v. 49, pt. 2, p. 840-845, 1916, incl. fig. no. 11-16, 2 tables. LC.(TF371,M41,v.49-2)

The same, v. 50, pt. 2, 1916, p. 899-905, incl. figs. no. 11-16. 1 diagr., 2 tables. LC.(TF371 M41,v.50-2)

"Specifications for bolts and nuts," p. 901. iv: Permissible variations. 5. Gage of bolts. 6. Threads.

186. [MASTER CAR BUILDERS' ASSOCIATION.]

Screw threads, bolt heads and nuts. Standard. (Master C. B. A.), v. 51, 1917, p. 565-572, incl. figs. 11-16, 1 diagr., tables i, ii, 2 folding plates (diagrs., tables). LC.(TF371M41,v.51)

187. MEASURING AND GAGING SCREW THREADS. (Am. Mach.), v. 46, no. 23, June 7, 1917, p. 1001-1003, incl. 9 figs. ES. LC.(TJ1,A5,v.46)

Fig. 1. Gage for pitch diameter and lead. Figs. 2, 3. Various gages for pitch diameter and lead. Figs. 4-9. Various gages for testing screw threads. Gages for measuring or testing taps or screws are briefly described.

Editor reminds the reader that the subcommittee of the A. S. M. E. is studying the question of screw-thread tolerances, and would be glad to receive further suggestions from all who are interested in this important problem.

188. MEASURING A 65-DEGREE V-THREAD. (Mach.), v. 24, no. 1, Sept., 1917, p. 63. 180 words. 1 fig. (diagrs.). LC.(TJ1M21,v.24)

189. MEASURING SCREW THREADS BY MEANS OF MICROMETERS. (Mach.), v. 19, no. 5. Jan., 1913, p. 384, incl. 1 fig., 1 table. Signed "A." LC.(TJ1M21,v.19)

190. METRISCHES S-I GEWINDE UND SCHRAUBENSCHLUESSELWEITEN. (V. D. I.), band xxxxiv. 2. halbjahr, 10. nov., 1900, p. 1556. 1 table. LC. (TA3 V5,v.44-2)

Short note.

Table: Skala der normaldurchmesser und der zugehoerigen ganghoehen und schluesselweiten.

191. A MICROSCOPE FOR MEASURING SCREW THREADS. (Am. Mach.), v. xxvii, part i, no. 3, Jan. 21, 1904, p. 78. 700 words, 7 figs. (3 half-tones, 4 diagrs.). LC. (TJ1A5,v.27-1)

Figs. 1-3. Screw measuring microscope. Figs. 4-6. Arrangement of cross wires and various adjustments.

192. MODERN FRENCH FIELD-GUN. (Eng.), v. lxxxiv, Dec. 6, 1907, p. 775-778. 16 figs. (sections, etc.), tables. ES. 9727 LC.(TA1,E55,v.84)

Constructed by Schneider et cie., Creusot and Havre, France.

193. MOORE, GEORGE R.

Size difference of bolts and nuts for "V" and standard threads. (Am. Mach.), v. xxx, pt. i. May 16, 1907, p. 691, incl. table. ES. 8675 LC.(TJ1 A5,v.30)

Table: Moore's table of size differences of bolts and nuts for "V" and standard threads.

194. THE NATIONAL PHYSICAL LABORATORY IN 1908. (Eng.), v. lxxxvii, March 26, 1909, p. 408-410; April 2, 1909, p. 445-447. ES. 15330 LC. (TA1,E55,v.87)

"The Engineering standards committee." Screw-gauges of five standard systems have been verized" . . . p. 446.

195. THE NATURE OF WORN THREAD CONTACT. (Ry. Mach.), v. ii, no. 4. Feb. 10, 1903, p. 171. 210 words. Pat. Off. Lib.

Refers to an article by Oscar J. Beale, on the subject, which had appeared in the Am. Machinist.

196. [NEWMAN, W. H.]

Screw gauges. Letter to editor by W. H. Newman, Totteridge, Herts, Feb. 10, 1917. (Eng.), v. ciii, no. 2668. Feb. 16, 1917, p. 163. 220 words. ES. LC.(TA1E55,v.103)

Relates to method of correcting the progressive error of the lead screw of a lathe by suitably chosen change wheels.

197. NOTROH, A. F.

Cutting a lead screw. Letter from A. F. Notroh, Providence, R. I. (J. Ry. App.), Feb., 1900, p. 407, incl. 1 fig. PO.

Fig.: The screw that was to be cut.

198. OBERG, ERIK.

Screw thread systems. By Erik Oberg, associate editor of Machinery. (Mach.), Shop edition, v. 14, no. 6, Feb., 1908, p. 251-253. 7 figs., 2 tables. ES.—Pam. LC.(TJ1M2,v.14)

Contents.—U. S. Standard thread.—The sharp V-thread.—The Whitworth Standard thread.—British Standard fine screw thread.—British Association Standard thread.—Briggs Standard pipe thread.—Whitworth Standard thread for gas and water piping.—Square thread.—The Acme thread.—French and international standard threads.—Instrument and watchmakers' system.—Lag screw threads.—Gas fixture threads.—Fine screw thread systems.

Footnote: ''The following articles relating to screw thread systems have been previously published in Machinery: Whitworth vs. Sellers thread, May, 1899; Screw pitches in foreign countries, Feb., 1900; Screws, Sept., 1903; Proposed standards for machine screws, June, 1906.''

198a. OTTERSON, J. E.

Munitions design for quantity manufacture. (Am. Soc. M. E.), Journal, v. 39, no. 5. May, 1917, p. 380-381. ES. LC.(TJ1A72,v.39)

This is an abstract of a paper for presentation at the spring meeting, Cincinnati, O., May 21-24, 1917, of the American Society of Mechanical Engineers.

Also in: (Iron Age), v. 99. May 10, 1917, p. 1135-1136; (Iron Trade Reiew, Cleveland, O.), v. 60 May 24, 1917, p. 1128-1129.

Deals with the question of the relation of design to quantity manufacture, under abnormal conditions.

199. PAJEKEN, J. F.

Metrisches gewinde. (V. D. I.), band xxxix, no. 2, 12. Jan., 1895, p. 51-52. 16 outline figs. LC (TA3 V5,v.39-1,1895)

Title: Metrical screw threads.

Treats on the production of screw threads in the factory of Ludwig Loewe & Co., Berlin.

199a. PATTON, THOMAS A.

Masked tolerances. Letters from Thomas A. Patton, Moores, Penn'a (Am. Mach.), v. 46, no. 16. April 19, 1917, p. 694-695. ES—LC(TJ1A5,v.46)

Treats on tolerances in manufacture of projectiles and munitions.

200. PAYET, J.

Note sur l'unification des pas de vis pour les appareils d'utilisation à gaz. Communication présentée au nom de Comité de la Société technique de l'industrie du gaz en France, au Congrès de 1902, par M. J. Payet, secrétaire. (S. E. I. N.), Bulletin. 101e année, 2e sémestre, juillet, 1902, p. 112-123. Figs., tables, 4,000 words. LC (T2S6,t.101)

''Système internationale de zletages en Suisse,'' p. 122-123.

Treats on the unification of the pitch of screw threads, being a discussion of the metric screw thread system for gas pipe and fittings suggesting also changes, proposing unification.

201. PAYET. J.

The standardization of screws for gas connections. [By] J. Payet, on behalf of the Société's Committee on the subject. (P.Eng.), v. 26, no. 801, July 4, 1902, p. 10. 800 words. LC (TJ1P8,v.26,1902)

Paper read before the Société technique de l'industrie du gaz, France, June, 1902.

Explains how the international system in use for rods and bolts may be applied to gas connections.

The question of the standard of screws in France was raised in 1891, by M. Sauvage at a meeting of the Society for Encouragement of National Industry, and a committee was appointed to deal with the subject.

202. Peam, Ferd.

The geometry of the square-thread screw. (Am. Mach.), v. xxvii, part ii, no. 43, Oct. 27, 1904, p. 1421-1424. 3,000 words, 6 outline figs. LC. (TJ1, A5, 1904, v. 27-2.)

Figs. 1-4. Showing the impossibility of square threads of infinite pitch. Fig. 5. Limiting case of a square thread screw. Fig. 7. Finding the form of the tool. Fig. 6. A square thread screw having six threads.

Shows how screws and nuts of low helix angle may be made a commercially perfect fit.

203. Peters, Th.

Metrisches gewinde (V. D. I.), v. xxxxii, no. 49. 3 Dec., 1898, p. 1367-1372. 3,500 words. 3 diagrs., 2 tables. LC. (TA3, V5, v. 42.)

"[Bibliography]:" Nachweis der literatur ueber schrauben-gewinde, im besonderen metrischer systeme, geordnet nach den jahren des erscheinens," p. 1370-1372.

This is a general review of the subject (Metric screw threads), referring especially to the Conference at Zuerich. A valuable bibliography chronologically arranged, is appended on p. 1370-1372.

204. Picard, Maurice.

Commission des filetages. Unification des filetages des vis horlogères. Rapport sur le projet présenté par M. Maurice Picard. (S. E. I. N.), Bulletin. 108e année, t. 112, 2e sémestre, no. 8, août, sept., oct., 1909, p. [366]-376. Tables. 1 fold. plate, (diagrs.) At head of title: Mécanique. LC. (T2S6, v. 112.)

Report on a proposal to standardize threads in watch and clock manufacturing, made to the Commission on Screw Threads of the Society for Encouragement of National Industry.

205. Pitch Diameters for Metric System Screw Threads. (Mach.), v. 19, no. 6, Feb., 1913, p. 441. 120 words. 1 table. LC. (TJ1, M21, v. 19.)

206. Pitch, Lead and Threads per Inch. (Mach.), v. 24, no. 3. Nov., 1917, p. 200. 430 words. LC. (TJ1M21, v. 24.)

207. Points on Making and Using Threading Chasers. (Mach.), v. 21. Aug., 1915, p. 1015-1016, incl. 4 diagrs. ES.—Pam. LC. (TJ1M2, v. 21.)

208. Porter, Charles T.

Finer screw threads. By Charles T. Porter, Montclair, N. J. Paper no. 958. (Am. Soc. M. E.), v. xxiv, Dec., 1902, p. 137-142, incl. Figs. 30, 31, 32 (diagrs.), table i. With discussion. LC. (TJ1, A7, v. 24.)

Author argues that the existing system reduces the area of cross-section of the bolt unnecessarily, and that the steep inclination allows the nut to jar loose easily.

Table shows system proposed.

208a. Powell, H. J. Bingham.

The gagemakers' inspection of his own product. (Am. Mach.), v. 48, no. 4. Jan. 24, 1918, p. 141-142. ES. LC. (TJ1A5, v. 48.)

Contents.—Help for gagemakers.—The question of tolerances.—Great accuracy necessary.—What happens with conditions as they are at present.

209. POWELL, H. J. BINGHAM.

Gaging screws. (Am. Mach.), v. 48, no. 25, June 20, 1918, p. 1045-1046. ES. LC. (TJ1, A5, v. 48.)

Contents.—Obtaining interchangeability.—The various sizes used.—The splitring screw gage.—An example.

210. POWELL, H. J. BINGHAM.

The inspection of screw gages for munitions of war. (Am. Mach.), v. 47, no. 25. Dec. 20, 1917, p. 1065-1073, incl. figs. 1-5, (half-tones). ES.—Pam. LC. (TJ1, A5, v. 47.)

Author is, Inspector in charge, Dept. of Gages and Standards, British Ministry of Munitions of War in U. S.

Contents.—The measurement of the pitch.—Devices for measuring pitch.—Pitch from thread to thread.—Leveling operations.—Ring screw gages.—Plug-screw gages.—The thread-micrometer principle.—One wire better.—Tolerance allowed.

Illustrations: 1. National Physical Laboratory projection machine. 2. Bingham Powell pitch machine. 3. Apparatus for taking true casts or ring screw gages. 4. National Physical Laboratory screw measuring machine. 5. Attachment placed in Pratt & Whitney measuring machine.

Aim of author is to assist screw-gage manufacturers in their work of making gages for munitions of war, which have to be accurate within very low tolerances.

The same article condensed, in: (Mach.), v. 24, Jan., 1918, p. 452-456.

An abstract of this article in: (Am. Soc. Mech. E.), Journal, v. 40, Jan., 1918, p. 108-109.

210a. POWELL, H. J. BINGHAM.

The relation of screw-thread angles to other functions. (Am. Mach.), v. 49, no. 13. Sept. 26, 1918, p. 571-573, incl. diagrs., 2 tables. ES. LC. (TJ1A5,v.49)

[Synopsis]: "In the discussion relative to the adoption of an international standard for screw threads the advocates of different angles for their slope and different forms for their roots and crests all have seemingly good reasons for advocating the adoption as an international standard one of the types now in use."

211. POWELL, H. J. BINGHAM.

Screw gage measuring machine. (Am. Mach.), v. 47, no. 20. Nov. 15, 1917, p. 840-842, incl. figs. 1-3 (sections, etc.). ES. LC. (TJ1, A5, v. 47.)

212. [PRATT & WHITNEY CO., HARTFORD, CONN.]

The milling-cutter applied to the production of screw-threads. (Eng. N.), v. xlix, no. 1, Jan. 1, 1903, p. 21-23. 4 figs., (half-tones). ES. LC. (TA1, E6, v. 49, 1903.)

Figs. 1, 2. Front and rear view of 6x14-in. thread-milling machine. Fig. 3. Milling-cutter used on thread-milling machine. Fig. 4. Specimens of work done on thread-milling machine.

213. PRECISION SCREW MEASURING MACHINE. (Mach.), v. 24. Feb., 1918, p. 494-495, incl. 4 figs. (half-tones, diagrs., etc.) ES.—Pam. LC. (TJ1M2, v. 24.)

A description of precision screw-measuring machine made by the Cambridge Scientific Instrument co., ltd., Cambridge, Eng.

It was made for the small screw-gage committee of the British Association for testing accuracy of commercially produced screw-threads and taps.

214. PROPOSED CHANGE IN PIPE THREAD. (Autom. Ind.), v. xxxix, no. 5. Aug. 1, 1918, p. 180. 270 words. LC. (TL1, A6, v. 39.)

Short review of the work on the subject by various committees.

215. PROPOSED MODIFICATION OF WHITWORTH THREAD. (Iron Age), v. 99. April 12, 1917, p. 930, incl. diagrs. LC. (T1, I7, v. 99.)

Relates to an article by W. C. Unwin, in Engineering, Feb. 16, 1917, which see (no. 300).

216. PROPOSED SCREW THREAD COMMISSION. (Am. Soc. M. E.), v. 40, no. 5. May, 1918, p. 421. ES. LC. (TJ1, A72, v. 40.)

From Iron Age, N. Y., April 4, 1918, p. 870-871.

217. PROPOSED SCREW-THREAD LEGISLATION. (Soc. Autom. E.), v. ii, no. 3, March, 1918, p. 229. LC. (TL1S5, v. 2.)

Relates to the history of the bill by Hon. John Q. Tilson, M. C., from Conn., introduced in the H. R. on March 5, 1918, and its aims.

218. PROPOSED STANDARDS FOR MACHINE SCREWS. (Ry. Mach.), June, 1906, p. 520-522. vi tables. Diagrs. Pat. Off. Lib.

Tables show the various standard threads.

219. PROPOSED UNIFORM SYSTEM OF SCREW THREADS FOR FRANCE. (Am. E. R. J.), v. lxvii, (new series v. vii), no. 12, Dec., 1893, p. 584-585. 1 table, 1 formula. LC. (TF1A3, v. 67, 1893.)

Formula and table giving the pitch, length of screw of different trade numbers.

Abstract from Bulletin de la Société d'encouragement pour l'industrie nationale.

220. A PROPOSED UNIFORM SYSTEM OF SCREW THREADS FOR FRANCE. (Inst. Civ. E.), v. cxiv, 1892-93, p. 442-444, incl. 1 table. ES. 9399. LC. (TA1, I6, v. 114.)

Abstract from a report of the commission appointed by the Society for Encouragement of National Industry, in its bulletin, 1893, p. 173.

The original paper contains also a memoir by Mr. Marre, of the firm Bariquand et Marre, on the "Manufacture of triangular screw threads." See no. 175.

221. RANTSCH, EDWARD J.

Lathe gears for cutting metric screws. (Am. Mach.), v. 48, no. 11, March 14, 1918, p. 442, incl. table, formulas. ES. LC. (TJ1, A5, v. 48.)

222. REVISION OF PIPE-THREAD STANDARDS. (Power), v. 48, no. 7. Aug. 13, 1918, p. 250. 500 words. ES. LC. (TJ1, P7, v. 48.)

Discusses the labors of the committee on the revision of pipe threads, appointed by the Am. Society for Testing Materials, in Jan., 1915.

223. RICHARD, GUSTAVE.

Notes de mécanique. Application des règles du système francais de filetage pour les vis mécanique au matériel de la Compagnie de l'Ouest. See France. Compagnie de Chemin de Fer de l'Ouest.

224. RICHARD, GUSTAVE.

Notes de mécanique. Application des règles du système francais de filetages. Outils de taraudage établis par la Société Alsacienne de con-

structions mécanique. (S. E. I. N.), 97e année, 5e série, t. iii, no. 1, janvier, 1898, p. 84-85, incl. 5 figs. LC. (T2, S6, v. 3, 1898.)

225. RICHARDS, W.
The production of screw-thread gages. (Mech. W.), March 24, 1916. 2,000 words. Illus. LC. (TJ1, M55, 1916.)

226. ROBERTS, A. W.
Device for measuring thread gages. (Am. Mach.), v. 47, no. 4. July 26, 1917, p. 135. 600 words, incl. 1 half-tone.
ES. LC. (TJ1, A5, v. 47.)
Illustration shows a very simple and comparatively inexpensive device evolved by Mr. Roberts.

227. RODGERS, L. J.
Compensating screw threads for shrinkage. (Mach.), v. 20, no. 7. March, 1914, p. 585, incl. formulas. ES.—Pam. LC. (TJ1M2, v. 20.)

228. ROGERS, WILLIAM A.
On a practical solution of the perfect screw problem. By W. A. Rogers, Cambridge, Mass. Paper cxlvi. (Am. Soc. M. E.), v. 5, 1884, p. 216-259. With discussion. 1 fig. (no. 65), 6 tables. 3 fold. plates (diagrs.)
LC. (TJ1, A7, v. 5, 1884.)

229. ROLLED THREADS FOR SCREW SHELLS. (Mach.), v. 22, Feb., 1916, p. 510, incl. 4 figs., tables i-iv. ES.—Pam. LC. (TJ1M2, v. 22.)
The same article was published in: (Elec. W.), v. 67, no. 5. Jan. 29, 1916, p. 260, under title: Standardization of threads of sockets and lamp bases. See no.

230. ROLLING INTERNAL THREADS. (Mach.), v. 24, no. 2. Oct., 1917, p. [162]. 260 words. LC. (TJ1M21, v. 24.)

231. ROWELL, WILLIAM S.
Measurement of internal threads. (Mach.), v. 24, no. 5. Jan., 1918, p. 429, incl. 2 figs., formulas. LC. (TJ1M21, v. 24.)

232. ROWELL, WILLIAM S.
Wear of micrometer screw nut. Letter to editor. (Mach.), v. 24, no. 2. Oct., 1917, p. 156. 360 words, incl. 2 figs. LC. (TJ1M21, v. 24.)

233. S. A. E. STANDARD THREADS. (Mach.), v. 21, no. 6, Feb., 1915, p. 459. 420 words. ES.—Pam. LC. (TJ1M2, v. 21.)

234. SAUVAGE, ED.
Congrès international pour l'unification des filetages à Zurich, du 2 au 4 octobre, 1898. (S. E. I. N.), 97e année, 5e série, t. iii, no. 10, octobre, 1898, p. [1269]-1273. LC. (T2, S6, v. 3, 1898.)

235. SAUVAGE, ED.
Filetage international. Ouvertures de clefs pour les vis du système international. (S. E. I. N.), 99e année, 5e série, t. vi, no. 11. Nov., 1900, p. [671]-672. 1 table. LC.(T2,S6,v.6,1900)

236. [SAUVAGE, ED.]
International system of screw threads. (Inst. Civ. E.), v. cxxxvi, 1898, p. 408-409. ES. 9421 LC.(TA1 I6, v.136)

This is an abstract from an article by M. Sauvage, in: Revue de mécanique, 1898, p. 407.

The article deals with an International Congress held at Zurich in Oct., 1898, on the above question, with delegates from France, Germany, and Switzerland, and states details of system adopted.

237. SAUVAGE, ED.

Mémoire sur l'unification des filetages, par Ed. Sauvage. (S. E. I. N.), 92e année, 4e série, t. viii, avril, 1893, p. 179-242, incl. 55 figs. (diagrs., sections, etc.), tables, formulas. LC.(T2S6,v.92,1893)

"Bibliographie:" p. 242.

238. SAUVAGE, ED.

Observation sur le filetage Whitworth. (S. E. I. N.), 116e année, 1er sémestre, t. 127, no. 1. Janvier-fév., 1917, p. 354. 240 words. 3 fold. plates, tables. LC. (T2S6,v.127)

239. SAUVAGE, ED.

La question des filetages en Allemagne. (S. E. I. N.), 92e année, 4e série, t. viii, Sept., 1893, p. 704-706. LC.(T2,S6,v.92,1893)

At head: Extraites des publications françaises et étrangères.

This is an extract from an article published in the "Zeitschrift des vereins deutscher ingenieure," 1893, p. 473-515, in which interesting details are given of the projects for the standardization of screw-threads being studied (at the time).

240. SAUVAGE, ED.

Règles pour la construction des vis mécaniques. (Rev. M.), mai, 1897. 4000 words. CE.—E.

Rules for the construction of machine screw-threads.

Author reviews the new metric system for screw threads, and the standard wire gauge system adopted by the Society of Encouragement of French Industry, shows screw proportions and gives a comparison of that system with English and American threads.

241. SAUVAGE, ED.

Le système internationale de filetage à base métrique. Communication présentée à la conférence génerale des poids et mesures réunie à Sèvres en octobre, 1904, par M. E. Sauvage. (S. E. I. N.), 101e année, 1er sémestre, t. 102, Janvier, 1902, p. 130-132. LC.(T2S6,v.102)

242. SAUVAGE, ED.

Unification des filetages. Congrès international de Zurich. Système international de Zurich. Système international de filetages, à base métrique, pour les vis mécaniques, par M. E. Sauvage, Membre du conseil. (S. E. I. N.), 98e année, t. iv, 5e série, no. 3, mars, 1899, p. 421-457. 1000 words. 4 figs. LC.(T2,S6,v.4,1899)

"Bibliographie relative aux filetages spécialement aux filetages à base métrique, par ordre chronologique," p. 454-457 (from Zeitschrift deutscher ingenieure, Berlin, 3 Dec., 1898, p. 1370).

The above represents the full report of the International Congress for the standardization of metric screw-threads, held at Zurich, 1898, together with the text of discussions and an elaborate bibligraphy on the subject.

243. SCHLINK, F. J.

Method of indicating screw threads. (Mach.), v. 22. May, 1916, p. 800. 240 words, incl. 1 outline cut. ES.—Pam. LC.(TJ1M2,v.22)

Describes a simple and yet perfectly explicit convention for delineating the threads of screws.

244. Screw and Wedge Breech-Mechanism. (Eng.), v. lxxxv, Feb. 14, 1908, p. 207. See also no. 2, no 19. ES. 15328 LC.(TA1,E55,v.85)

245. Screw Gages. (Sci. Am. S.), v. lxxxiv, Nov. 24, 1917, p. 333. ES. LC.(T1F52,v.84)

Relates to Col. Crompton's paper on some notes on screw gages, presented before the Institution of Automobile Engineers, London.

246. Screw Gauges. (Engi.), v. cxxi, no. 3143. March 24, 1916, p. 263-264. 3 figs. (sections, etc.). ES. LC.(TA1E5,v.121)

Fig. 1. Method of carrying micrometer in lathe. Fig. 2. Cheap apparatus for measurement of thread angles. Fig. 3. Eyepiece being rotated until wire is just touching crests of threads.

Refers to Mr. W. Taylor's method shown in Report no. 38, Engineering standards committee.

247. Screw Gauges. Report of committee to the British Association, Liverpool meeting (Eng.), v. lxii, Oct. 16, 1896, p. 509-510. 7 figs. (sections), 3 tables. ES. 10985 LC.(TA1E55,v.62)

Contents.—The past.—ii. The present.—iii. The future.

Appendix i. Enlarged shadow photographs of screws, by Col. Watkin, C. B., R. A., etc.—Appendix ii. Gauges for verifying the accuracy of screws (for workshop use only), by A. Stroh.—Appendix iii. Working dimensions in mm. and 1000th of an inch.

This is the report of a committee appointed to the British Association, ''to consider means by which practical effect can be given to the introduction of the screw gauge proposed by the association in 1884.'' Chairman, W. H. Preece. Secretary, Conrad W. Cooke. Members: Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Major-General Webber, R. E. Crompton, A. Stroh, A Le Neve Foster, C. H. Hewitt, G. K. B. Elphinstone, T. Buckney, Col. Watkin, E. Rigg, and W. A. Price.

248. Screw-Measuring Machine at the National Physical Laboratory. (Eng.), v. lxxvi, Nov. 13, 1903, p. 660-661. 1200 words. 9 figs. (3 half-tones, 6 sections. ES. LC.(TA1E55,v.76)

Description of a machine for testing with aid of micrometer, the accuracy of commercially produced screw threads and taps.

The machine was constructed by the Cambridge Scientific Instrument co., ltd., for the N. P. Laboratory.

249. Screw Pitches in Foreign Countries. (Mach.), v. 6, no. 6, Feb., 1900, p. 164-166. 1600 words. 5 tables. LC.(TJ1M2,v.6)

Sub-title: Data upon the pitches of screws used abroad and the gearing for cutting them.

250. Screw Pitches in Foreign Countries. Data upon the pitches of screws used abroad and the gearing for cutting them. (J. Ry. App.), Feb., 1900, p. 388-389. 5 tables. Pat. Off. Lib.

251. Screw Thread Commission. (Iron Age.), v. 101, no. 14. April 4, 1918, p. 870-871. LC.(T1 I7,v.101)

Bill before the House [of Representatives] to establish a national standard of supreme importance.

251a. Screw Thread Commission Organized. (Soc. Autom. E.), Journal, v. iii, no. 4. Oct., 1918, p. 288. ES. LC.(TL1S6,v.3)

This first meeting of the Commission for Standardization of screw threads was held Sept. 12, 1918, at the U. S. Bureau of Standards, Washington. It was largely for the purpose of organization, since the members of the commission had not been formally appointed. The commission consists of: Dr. S. W. Stratton, Chairman; Lieut. Col. E. C. Peck, Ordnance dept.; Major O. B. Zimmerman, Engineers; Comdr. S. M. Robinson, Comdr. L. J. Marquart, U. S. Navy; Mr. Edwin H. Ehrman, H. T. Herr, for the S. A. E.; James Hartness and F. O. Wells, representing the A. S. M. E.

The following sub-committees have been formed: 1. Systems, including questions relative to profile, pitch and diameter. 2. Classification, including questions relating to tolerances, allowances and nomenclature. 3. Gages and methods of testing and specifications. Mr. H. W. Bearce will act as secretary, and Mr. R. Lacy as assistant secretary to both, the commission and the sub-committee; to the latter Mr. H. L. Van Keuren will also act as assistant secretary.

252. Screw Thread Measurement. (Iron Age), v. 99, no. 15. April 12, 1917, p. 894-895, incl. 7 figs. (diagrs., etc.). LC.(T1 I7,v.99)

From paper read before the Liverpool Engineering Society.

Sub-title: Some of the accurate methods used in gage making.

252a. Screw Threads. (P. Eng.), v. 58, no. 1646. Sept. 12, 1918, p. 126. 520 words. ES. LC.(TJ1 P8,v.58)

Sub-title: British standard fine (B. S. F.) screw threads and their tolerances.—Report no. 84, 1918.

This is a review of Report no. 84, 1918, of the Engineering Standards Committee, which supersedes the previous Report no. 38.

It is a report on the ''Tolerances of British standard fine (B. S. F.) screw threads, of the British Engineering Standards Association. There are two appendices to the report, one defining the terms ''grade'' and ''play'' as applied to a screw thread, the other showing how the formulae for determining the reduction in effective diameter required to compensate errors in angle and pitch are obtained.

253. Screw Thread Tolerances. (Horseless A.), v. 39, no. 4. Feb. 15, 1917, Engineering section, p. 4. 220 words. LC.(TL1 H81,v.39)

Short note. Relates to the hearing held before Congress relating to a proposed law on tolerances, etc.

254. Screw Thread Tolerances. (Mach.), v. 23, March, 1917, p. 614. 400 words. ES.—Pam. LC.(TJ1M21,v.23)

A brief note relating to the hearing in Feb., of Congress, with reference to the proposed law on standard tolerances, clearances, and allowances.

255. Screw-Thread Tolerances for Munitions. Special correspondence. (Am. Mach.), v. 48, no. 4. Jan. 24, 1918, p. 135-136, incl. 3 figs. (diagrs., sections), tables i-iv. ES. LC.(TJ1 A5,v.48)

Figs. 1-3. Screw-thread tolerances.

Table i. Tolerances for close fits. ii. . . . for medium fits. iii. . . . for loose fits. iv. U. S. standard screw-thread dimensions.

256. Sebert, H.

Note sur les dispositions proposées par le Département de la Marine (direction des constructions navales de Brest) pour l'unification des vis de petit calibre, par M. le général Sebert. (S. E. I. N.), Bulletin. 110e année, t. 115, no. 3, mars, 1911, p. 373-383. 2 tables. 3500 words. LC.(T2S6,v.115)

At head of title: Commission des filetages.

Proposals of the Bureau of Construction of the Navy Dept., France, for the standardization of small screw threads, presented for consideration to the Screw Thread Commission of the Society for the Encouragement of National Industry, France.

257. SEBERT, H.

Unification des filetages. Note en réponse à une demande de M. le Commandant de l'Aviation Navale britannique, à Paris. Par H. Sebert, Président de la Commission des filetages. (S. E. I. N.), 115e année, 1er sémestre, t. 125, no. 1, janvier-fév., 1916, p. 44-46. LC.(T2 S6,v.125).

257a. SECURING ANY KIND OF FIT DESIRED. (Am. Mach.), v. 46, no. 11, March 15, 1917, p. 450. ES. LC.(TJ1 (5,v.46)

Treats on fits, limits and tolerances.

258. SELLERS, WILLIAM.

On a system of screw threads and nuts. Paper read by William Sellers, Esq., President of the Franklin Institute, April 21, 1864. (Frank. I.), v. 77, 1864, p. 344-351, incl. 5 tables. Plate no. ii, iii. ES. 11429

Committee appointed to investigate the question of a proper system of screw threads, bolt-heads, and nuts for the general adoption by American engineers, consisted of: W. B. Ement, C. T. Parry, J. V. Merrick, J. H. Towne, C. Sellers, B. H. Bartol, Edw. Longstreth, Jas. Moore, and J. W. Murphy.

''Mr. E. Longstreth exhibited an instrument for setting the tools of screw-cutting lathes, so as to bring the point of the tool at right angles with the surface to be cut. It consists . . .''

259. THE SELLERS OR FRANKLIN INSTITUTE SYSTEM OF SCREW-THREADS. (Frank. I.), v. 123, 1887, p. 261-276. ES. 14374

Correspondence from various domestic and foreign sources, grown out of an inquiry addressed to the Institute by the Society of German Engineers of Berlin.

260. THE ''SELLERS'' OR FRANKLIN INSTITUTE SYSTEM OF SCREW-THREADS. (Inst. Civ. E.), v. lxxxix, 1887, p. 541-542. ES. 9375 LC.(TA1 I6,v.89)

Abstract of article in: Journal of the Franklin Institute, April, 1887, p. 261.

The Sellers system was favorably reported by a committee of the Franklin Institute, and adopted by the U. S. Govt. in 1868.

260a. SHEFFIELD THREAD-LEAD TESTING MACHINE FOR SCREW GAGES. (Am. Mach.), v. 49, no. 4. July 25, 1918, p. 180, incl. 1 half-tone. ES. LC.(TJ1A5,v.49)

Description of a testing machine for the lead of screw-thread gages. The machine has been placed on the market by the Sheffield Machine and Tool co., Springfield, O.

261. SHRIER, F. W.

Measuring diameters of screw threads. (Mach.), v. xxiv, March, 1918, p. 648, incl. 1 fig. ES.—Pam. LC.(TJ1M2,v.24)

262. A 600,000 POUNDS SCREW-TESTING MACHINE. Editorial correspondence. (Am. Mach.), v. xxviii, part ii, no. 51, Dec. 21, 1905, p. 833-836. 1000 words. 1 half-tone, 3 outline figs. (sections, diagrs., etc.). LC. (TJ1 A5,v.28-1)

Article describes a fine machine recently perfected for the University of Illinois.

263. [SKERRETT, W. H. W.]

Standard test specimens. In his: Development of gun manufacture, by W. H. W. Skerrett, Inspector of Ordnance, O. R. C., U. S. A. (Soc. Autom. E.), Journal, v. iii, no. 2, Aug., 1918, p. 153-164. With discussions. 11 outline figs. (illus., sections, etc.). LC.(TL1 S6,v.3)

264. SMART, H.

Pitch diameter of 90-degree threads. (Mach.), v. 21. Aug. 1915, p. 1011, incl. diagrs. ES.—Pam. LC.(TJ1M2,v.21)

265. SMITH, DAVID J.

The repair of motor vehicles. (Inst Autom. E.), v. vi, session 1911-12, p. 132-194, incl. discussion and correspondence. PO.

p. 152-153, 163, 170-171, 183 contain remarks on screw threads.

"Standardization," p. 152-153.

". . . The question of screw threads is one of the most pressing of repairers' troubles," p. 153.

Col. Crompton remarks concerning interchangeability of screw threads and his work at the subject for the Standard committee, p. 170-171.

266. SNOW, OLIN.

Cap-screws, bolts and studs. Letter to the editor. (J. Ry. App.), May, 1899, p. 120, incl. 2 figs. (sections). Pat. Off. Lib.

267. [LA SOCIETE ALSACIENNE DE CONSTRUCTIONS MECANIQUES.]

Applications du système francais de filetages. (S. E. I. N.), 97e année, 5e série, t. iii, janvier, 1898, p. 84-85, incl. figs. 1-5 (7 sections). LC.(T2 S6,v.3,1898)

268. [SOCIETE D'ENCOURAGEMENT . . .]

Unification des filetages. (S. E. I. N.), 103 année, t. 106, no. 9. 30 sept., 1904, p. 647-663. 6000 words. Tables. LC.(T2,S6,v.106,1904)

"Note sur un projet tendant à l'unification des petites vis d'un diamètre inférieur à six mm.," par. M. E. Sartiaux, Président du Syndicat professionnel des industries électriques, p. 649-651.

"Rapport de la deuxième commission du Syndicat professionnel des industries électriques. Étude et propositions sur l'unification des vis en dessons de 6 mm.," p. 651-652.

"Résumé du rapport de M. le général Sebert," p. 652-654.

"Résumé du rapport de M. Bariquand et Marre," p. 655.

"Résumé du rapport de M. Sauvage," p. 655-663.

Introduction is signed: "Pour le Bureau: Le President de la Société d'Encouragement. H. Le Chatelier."

269. [SOCIETE D'ENCOURAGEMENT . . .]

Unification des filetages. Règles d'etablissement des boulons, goujons et vis employés dans les constructions du matériel de transport. (S. E. I. N.), 116e année, 2e sémestre, t. 128, no. 4, juillet-août, 1917, p. [84]. 150 353. 26 figs., 4 fold. plates, tables. LC. (T2S6,v.127)

270. [SOCIETE D'ENCOURAGEMENT . . .]

Unification des filetages. Règles d'etablissement des boulons, goujons et vis employés dans les constructions du matérial de transport. (S. E. I. N.), 116 année, 2e sémestre, t. 128, no. 4, juillet-août, 1917, p. 85. 150 words. LC.(T2S6,v.128)

271. SOCIETY OF AUTOMOTIVE ENGINEERS, N. Y.

Current standardization work. (Soc. Autom. E.), Journal, v. ii, no. 5, May, 1918, p. 370-374. 3 tables. LC. (TL1S6,v.2)

Contents.—Aeronautic division meeting. (Subjects: Airplane nuts, bolts, and turnbuckles.)—Bolt diameter limits.—Bolt thread lengths.—Bolt head and nut dimensions.—Bolt head and nut chamfer.—Bolts with threaded ends.—Plain ball hexagon bolt heads, p. 370.—Turnbuckles.—Data sheets div. meeting.—Indexing system.—Size of data sheets.—Altitude curves.—Electrical equipment div. meeting.—Starting switches, p. 371.—Cable terminals.—Marking of fuses.—Mounting dimensions for electrical instruments.—Distributor mounting dimensions.—Generator bracket mounting.—Starting motor mounting.—Nomenclature div. meeting.—Nomenclature for aeronautics, p. 372.—Tire and rim div. meeting, p. 373.—Routine test of rims.—Pneumatic tire sizes for passenger cars.—Carrying capacity and inflation pressures.—Motorcycle tires.—Valve holes.—Rim sections (base bands) for solid tires.—Wood spokes.—Coöperation with tire and rim association.—Data sheet correction, p. 374.

272. SPRINGER, J. F.

A method of finding sizes of rolled thread screw blanks. (Am. Mach.), v. xxxiii, part i, May 26, 1910, p. 971-972, incl. 3 figs., formulas.

ES. 15694 LC.(TJ1 A5,v.33-1)

Sub-title: Only an approximate diameter formula can be derived.

273. SPRINGER, J. F.

Principles of thread rolling and the setting of the dies. (Am. Mach.), v. xxxiii, part i, April 21, 1910, p. 739-741, incl. 4 figs., formulas.

ES. 15694 LC.(TJ1 A5,v.33-1)

Sub-title: Determining pitch, angle of thread and position of the dies.

274. STABEL, JOS. M.

Measuring external thread diameters. (Mach., Eng. ed.), v. 2, no. 5. Jan., 1904, p. 248-250. 1600 words. 3 figs., 3 tables. LC. (TJ1M21,v.2)

Sub-title: •Method of thread measurement by means of wires and micrometers.

275. STAMBKE.

Referat ueber den gegenwaertigen stand der frage betreffend die einfuehrung eines metrischen gewindesystems. (Annalen fuer gewerbe und bauwesen, hrsg. von F. C. Glaser, Berlin), Band 43, Nov. 1, 1898, p. 173-178, incl. 1 double-page table. PO.

"Vorschlaege fuer ein einheitliches gewindesystem," p. 174-178.

Statement regarding the present status of a uniform standard metric screw-thread system, with reference to the Swiss conference, by Chief building inspector Stambke, in behalf of the German Railroad Association.

276. THE STANDARDIZATION OF SCREW THREADS. (Eng.), v. 69, Jan. 19, 1900, p. 75-77; Feb. 2, 1900, p. 143-145; Feb. 9, 1900, p. 176-179, incl. 17 figs., (Diagrs., sections, etc.), tables i-xx. ES. LC. (TA1, E55, v. 69.)

277. THE STANDARDIZATION OF SCREW THREADS. (Eng.), v. ciii, no. 2676, April 13, 1917, p. 360, incl. 4 figs. (diagrs.), 1 table.

ES. LC. (TA1, E55, v. 103.)

Table: The standardization of screw threads; the Whitworth thread.

Article refers to a questionnaire sent out by the Engineering Standards Committee regarding the advisability of standardizing screw threads, including a letter from the secretary, Mr. C. Le Maistre.

278. STANDARDIZATION OF SCREW THREADS. (Am. Mach.), v. 48, no. 26, June 27, 1918, p. 1103.
ES. LC.(TJ1 A5,v.48)

Remarks concerning H. R. bill 10852, on standardization of screw-threads by the editor, and text of bill.

279. STANDARDIZATION OF THREADS OF SOCKETS AND LAMP BASES. (Elec. W.) v. 67. Jan. 29, 1916, p. 260. ES. LC. (TK1, E5, v. 67.)

The same in: (Mach.), v. 22. Feb., 1916, p. 510. LC.(TJ1M21,v.22)

280. STANDARDIZING SYMBOLS FOR SCREW-THREAD NOTATION AND FORMULAS. (Am. Mach.), v. 47, no. 8. Aug. 23, 1917, p. 326, 350 words, incl. symbols for screw-thread formulas. ES. LC. (TJ1, A5, v. 47.)

281. STANDARD SCREW THREADS AND LIMIT GAUGES. (Mech. Eng.), v. 13, no. 323, April 2, 1904, p. 482. 220 words. LC. (TJ1M4, v. 13.)

282. STANLEY, F. A.

Gages for Briggs standard pipe threads and for standard oil well casing. (Am. Mach.), v. 28, no. 18. May 4, 1905, p. 575-580. 10 figs. (half-tones, sections, etc.) LC. (TJ1, A5, v. 28.)

283. STEELMAN, JAMES.

The rollign of screw threads. (Cass. E. M.), July, 1916. 3,800 words. LC. (TA1C34, 1916.)

284. STETSON, GEORGE R.

Franklin Institute standard screw thread. (Frank. I.), v. 107, 1879, p. p. 244-247. ES. 11459.

Letter by Mr. Stetson, p. 244-247, addressed to the Committee on Publication, Franklin Inst., Phila., dated, New Bedford, Mass., Feb. 10, 1879.

285. [STOREY, J. E.]

Methods of correcting inaccuracies of screw threads. (Mech. E.), v. xvii, no. 429. April 14, 1906, p. 529-530, incl. 2 figs. (sections, etc.). 700 words. LC. (TJ1M4, v. 17.)

Describes a method recently patented by J. E. Storey and the Newall Engineering co., ltd., Atherton's Quay, Warrington. It can be applied to measuring apparatus, dividing machines, and other instruments of precision.

[SUPLEE, HENRY HARRISON. See REULEAUX, FRANZ.

286. SUPLEE, HENRY HARRISON.

Metric screw threads. (J. Ry. App.), Feb., 1900, p. 389.
Pat. Off. Lib.

287. SUPLEE, HENRY HARRISON.

Metric screw threads. (Mach.), v. 6, no. 6, Feb., 1900, p. 165. 600 words. LC. (TJ1 M2, v. 6.)

Author shows that it is not necessary to equip American lathes with metric lead screws, and describes the change gears which enable metric screws to be cut with English lead screws.

288. SWEET, JOHN E.

Screw threads most in use. (Am. Mach.), v. xxx, pt. :, June 20, 1907, p. 888-889. ES. 8675. LC. (TJ1, A5, v. 30-1.)

Brief discussion of the various thread systems.
Under heading: "Practical letters from our readers."

289. SYSTEME INTERNATIONAL DES FILETAGES A BASE METRIQUE. (Génie C.), 21e année, t. xxviii, no. 20 (no 979), 16 mars, 1901, p. 333. 1 table.
LC. (TA2 G3, v. 28.)

290. TAP AND SCREW LIMITS.
(Mach.), v. 22, no. 1. Sept., 1915, p. 54-57, 4,000 words, incl. 7 figs., 1 table. LC. (TJ1M21, v. 22.)
Sub-title: The importance of obtaining more intelligent specifications for taps and threading dies.

290a. TESTING SCREW THREADS. (Sci. Am. S.), v. lxxxv, no. 2215. June 15, 1918, p. 380; 381, incl. 3 figs. (diagrs., sections).
ES. LC. (T1F25, v. 85.)
From "The Engineer."
Sub-title: Optical projection apparatus for securing accuracy.

291. THOMPSON, WILFRID J.
Wear in micrometer screw. Letter to editor. (Mach.), v. 24, no. 4. Dec., 1917, p. 346-347. 250 words. LC. (TJ1M21 v. 24.)

292. THORN, LEONARD M.
Rethreading fixture. (Am. Mach.), v. 48, no. 3. Jan. 17, 1918 p. 19. 350 words, incl. 1 fig. ES LC. (TJ1, A5, v. 48.)
Figure shows fixture for rethreading used, and found to be a great saving over the old way.

293. THORN, LEONARD M.
Thread-lead gage. (Am. Mach.), v. 47, no. 25. Dec. 20, 1917, p. 1092. 230 words, incl. 1 fig. ES. LC. (TJ1 A5 v. 47.)
See also Woodworth, Walter J.

294. TOOLS FOR EXTRACTING BROKEN SET SCREWS. (Iron Age), v. 99, no. 3. Jan. 18, 1917, p. 191, 320 words, incl. 1 half-tone. (3 figs.)
(T1, 17, v. 99.)
Describes a tool for extracting broken set and cap screws, studs, staybolts, etc., developed by the Cleveland Twist Drill co., Cleveland, O.

294a. TRACEY ANGLE FIXTURE, THREAD-MILLING ATTACHMENT AND LEAD-SCREW TESTER. (Am. Mach.), v. 49, no. 14. Oct. 3, 1918, p. 638-639, incl. 3 half-tones. ES. LC. (TJ1A5, v. 49.)
Illustrations.—1. "Beckett" universal angle fixture.—2. "Beckett thread-milling attachment.—3. "Lea" lead-screw tester.

295. TROWBRIDGE, AMASA.
Comparison of screw thread standards. By Amasa Trowbridge, Hartford, Conn. Paper no. 1,200. (Am. Soc. M. E.), v. 30, 1908, p. [373]-384, incl. 3 diagrs., 1 table, formulas. With discussion.
ES. 14655. LC (TJ1, A7, v. 30.)
Formulas, p. 379: U. S. standard, British fine standard, Bond standard, Lewis standard, proposed intermediate standard.

296. TYLER, CHARLES C.
A proposed standard for machine screw thread sizes. (Am. Soc. M. E.), Paper no. 944. v. xxiii, May, 1902, p. 603-631. 3,500 words. Figs. no. 256-256 (half-tones, sections, etc.), tables i-v, and 3 tables. (TJ1, A7, v. 23.)
Contents.—Form of thread.—Diameters of screws.—Pitch of screws.—Modi-

fication of thread form.—Standard reference thread gauges.—Basic standard reference thread gauges.—Standard reference thread gauges for screws.—The same, for taps.—Working gauges for screws.—The same, for taps.—Limits of variation in screw and tap diameters.—Limits of variation in screw and tap pitches.—Special indicating instruments.—Discussion.

Author calls attention to the inconvenience caused from the variation in size and proposes a standard having an angle of 60 degrees and a flat at the top of the thread equal to 1-8 of the pitch.

297. L'UNIFICATION DES FILETAGES A L'ÈTRANGER. (S. E. I. N.), 97 année, 5e série, t. iii, février, 1898, p. [203]-219. LC.(T2,S6,v.3,1898)

''Rapport sur l'état de la question de l'unification des systèmes de filetages et de jauges,'' p. 204-210.—Programme pour le Congrès international à convoquer éventuellement, p. 210-219.

298. UNIFICATION DES FILETAGES DE VIS. (Tech. M.), v. ii, no. 6, juin, 1910, p. 379.

299. UNIFORM SCREW THREADS FOR ALL COUNTRIES. Special correspondence. (Am. Mach.), v. 49, no. 3. July 18, 1918, p. 117-119. ES. LC.(TJ1 A5,v.49)

Article discusses several interesting points brought out in the report of E. H. Ehrman to the S. A. E. concerning the results of the screw-thread conference held by the International Standards Committee in London.

300. UNWIN, WILLIAM CAWTHORNE.

A suggested modification of the Whitworth screw thread. (Eng.), v. ciii, no. 2668, Feb. 16, 1917, p. 158-159. 1600 words. 2 figs. (diagr., etc.), 4 tables. ES. LC.(TA1E55,v.103)

Author aims to find means for interchanging the Whitworth screw with more facility.

301. WALDMAN, JOSEPH.

Thread cutting tools. (Mach., shop edition), v. 20, no 1. Sept., 1913, p. 29-30. 3 outline cuts; p. 53-54. 3 figs. ES.—Pam. LC.(TJ1M2,v.20)

302. WAR DEPARTMENT TOLERANCES FOR SCREW THREADS. (Mach.), v. 25, no. 5. Jan., 1918, p. 457-458, incl. 3 figs., 1 table. LC.(TJ1M21,v.24)

Diagrams show War Dept. method of giving tolerances on screw threads.

Table: Ordnance Dept. table of tolerances for screw threads (U. S. standard form), p. 457.

303. WELLS, F. O.

Individual paper on the standardization of screw threads. (Am. Ry. M. M. A.), v. xlix, 1916, p. 70-81, incl. 9 figs. (half-tones, diagrs., sections), 3 tables, formulas. LC.(TF1 A5, v.49)

Contents.—Introduction.—The screw as basic.—The U. S. standard thread. —The V form of thread.—Standardization of screws and taps.—Tolerances.—Inspection.—Depth of thread in a tapped hole.—Lead and pitch diameter. Rake of taps and dies.—Safety first.

304. WELLS, F. O.

Standardization of screw threads. (Ry. R.), v. 58, June 24, 1916, p. 926-927. LC.(TF1 R4,v.58)

305. WELLS, F. O.

Taps and screws. By F. O. Wells and H. E. Harris. (Am. Soc. M. E.), Journal. v. xxiv, pt. 2, 1912, p. 1035-1063. With discussion. 7800 words,

incl. 19 figs. (half-tones, diagrs., etc.), tables 1-3. LC.(TJ1 T72,v.24-2)
Discusses some of the problems of tap and die making.

306. WHITNEY, ELAM.
Slotting and shaping in the automatic screw machine. (Am. Mach.), v. 48, no. 5. Jan. 31, 1918, p. 209, incl. 3 figs. (sections).
ES. LC.(TJ1 A5,v.48)
Figs. 1-3. Slotting and shaping attachment.
The tools described in this article are used at attachments for Brown & Sharpe automatic screw machine.

307. WHITWORTH, JOSEPH.
On a uniform system of screw threads. Communicated to the Institution of Civil Engineers, 1841. By Joseph Whitworth, Esq., Assoc., Inst. C. E. (Frank. I.), v. 33, 1842, p. 327-328. 1 table. ES. 11294
From London Mec. Mag., Oct., 1841.

308. WHITWORTH, JOSEPH.
On a uniform system of screw threads. (Inst. Civ. E.), v. i, 1837, p. 157-160. With discussion. 1 table. ES. 21150 LC.(TA1 I 6,v.1,1837)

309. WHITWORTH VS. SELLERS THREAD. (J. Ry. App.), May, 1899, p. 111, incl. 2 figs. (diagrs.) PO.

310. WILLIAMS, FRED. R.
The microscope for inspecting screws. (Am. Mach.), v. 46, no. 17. April 26, 1917, p. 736. 350 words, incl. 1 half-tone.
ES. LC.(TJ1 A5,v.46)
Illustration: The microscope and the fixtures used in adapting it for testing threads.
Author treats on accurate checking of hobs, taps, thread chasers, forming cutters and a number of other tools with cutting edges. . . . He also refers to the chapter on ''The use of the compound microscope in the toolroom'' in the work under the title: Accurate tool work, by Goodrich and Stanley.

311. WILSON, JOSEPH C.
Jigs for castings and steel parts. (Am. Mach.), v. xxxvii, no. 15, Oct. 10, 1912, p. 591-594, incl. 17 figs. (illus. and sections).
ES. LC.(TJ1A5,v.37)
Treats on important points in design and construction of special tools for various classes of work, including cast iron levers, dropforged pieces and small parts made from steel bars. Types of drill jigs and milling and grinding fixtures for different operations, where accurate locating and clamping devices are essential.

312. WOOD, JOHN A.
Conflict of one-half inch thread pitches. (Mach.), v. 22, no. 2. Oct., 1915, p. 148, incl. 3 outline cuts. ES.—Pam. LC.(TJ1M2,v.22)
With note by editor added to article.

313. WOODWORTH, WALTER D.
Making Whitworth thread gages. i. By W. D. Woodworth and Herman W. Bender. (Mach.), v. 24, no. 6. Feb., 1918, p. [483]-493, incl. 17 figs., tables 1-2. LC.(TJ1M21,v.24)

314. Woodworth, Walter J.

Criticism of thread-lead gage. (Am. Mach.), v. 48, no. 9, Feb. 28, 1918, p. 370. 250 words. ES. LC.(TJ1 A5,v.48)

Refers to short articles on the thread-lead gage by L. M. Thorn, which see.

315. Wright, Howard H.

Error in wire method of measuring worm threads. (Mach.), v. 24, no. 5. Jan., 1918, p. [429]-440, incl. 1 fig. (diagrs.). LC.(TJ1M21,v.24)

ADDITIONAL ENTRIES.

316. Bagnall-Wild, R. K.

The use and abuse of steel. By Lieut. Col. R. K. Bagnall-Wild and Lieut. E. W. Birch. (Inst. Autom. E.), v. xi, session 1916-17, p. 307-368, incl. 43 figs. (diagrs., etc.), tables. P.O.

With discussion and communications.

W. H. Sheahan in his paper entered under no 339 states: ''Manufacturers contemplating entering into this field, who are without previous experience in machining nickel steel and working to the fine tolerances the aircraft constructor demands, would do well to carefully read 'The use and abuse of steel' . . .''

317. British Engineering Standards Committee, Lond.

Report on British standard pipe threads for iron or steel pipes and tubes. (Revised Nov., 1909). Lond., pub. for the Committee by C. Lockwood & son, 1918. ES.

At end: ''British engineering standards association. Price list of British standard ass'n. Price list of British standard specifications and reports. July, 1918. (This list cancels all previous lists).''

''Report: ''Definitions.—Recommendations.''—Table. ''Schedule of sizes of British standard pipe threads,'' p. 14.

318. British Scientific Products Exhibition.

(Eng.), v. cvi. Sept. 6, 1918, p. 246-250, incl. figs. 4-11 (half-tones). ES. LC.(TA1E55,v.106)

''Optical projection apparatus,'' p. 248-249.

Fig. 10, 11. Optical projection compartor for testing for testing screw-threads.

319. Crompton, R. E. B.

Notes on screw gauges. By Col. R. E. B. Crompton. (Inst. Aut. E.), v. xi, session 1916-17, p. 173-220, incl. 12 figs. (diagrs., etc.), 1 table. P.O.

Discussion by W. Taylor, Col. Bagnall,Wild, A. H. Sturdes, Dr. R. T. Glazebrook, Capt. A. A. Ross, M. F. Ryan. Communications from: C. F. Halsall, Prof. A. Sharp, C. E. Stromeyer, A. A. Remington.

Contents.—Nomenclature, p. 173-174; 213—Short history, p. 174.—Tolerances on screwed work must Include allowances—Effect of excessive tolerance on strength—Effect of clearances, p. 182-183—Adoption of high crested taps, p. 183-184—Division of gauges into two classes. Means by which wear of gauges can be met. Gauging nuts, p. 184-185; 214—Angle and forms of thread, p. 185-186; 215.

320. Doorakkers, G.

Taps and dies for production work. i. (Engi.), v. cxxvi, no. 3269. Aug. 23, 1918, p. 151-152, incl. figs. 1-5 (sections, etc.); ii. no. 3270. Aug. 30, 1918, p. 186, incl. figs. 6-11 (charts, section). ES. LC.(TA1E5,v.126)

321. ENGINEERING STANDARDS COMMITTEE, London.

Report on British standard nuts, bolt-heads, and spanners. 3d issue. Leslie S. Robertson, . . . sec'y. Lond., pub. for the Committee by C. Lockwood & son, 1908. ES.

11 numb. l., incl. diagrs., sections, tables. 33cm. ([Report] no. 28. Rev., Nov., 1908). At head of title: The Engineering standards committee.

See also title entry no. 16.

322. ENGINEERING STANDARDS COMMITTEE, London.

Report on British standard screw threads. Leslie S. Robertson . . . sec'y. Lond., pub. for the Committee by C. Lockwood & son, 1913. ES.

13 numb. l., incl. diagrs., tables. 33cm. ([Report] no. 20. Revised Feb., 1913). At head of title: The Engineering standards committee.

''Nomenclature and definitions,'' 6, 7.

323. FISCHER, C. J.

A practical ring, plug, and snap gage system. (Mach.), v. 25, no. 3. Nov., 1918, p. 219-221, incl. 10 figs. (sections, etc.) LC.(TJ1M21,v.25)

Details of a gaging system in which the requirements in interchangeable manufacture have been met.

324. FUNNELL, H. M.

Thread-measuring formulas. (Am. Mach.), v. 49, no. 19. Nov. 7, 1918, p. 839. 350 words, incl. 1 diagr.

. . . ''When using the three-wire system of measuring threads the usual formulas given in various popular handbooks are correct only when the thread is standard, . . .

325. GARDNER, GUY H.

Cutting screw threads by a primitive method. (Mach.), v. 25, no. 3. Nov., 1918, p. 204. 380 words. LC.(TJ1M21,v.25)

. . . ''The following describes the manner in which a country jeweler used this scheme by winding wire around the rod on which the thread is to be cut as a guide . . . to do an otherwise impossible job'' . . .

326. GOVERNMENT COMMISSION ON SCREW THREAD STANDARDIZATION.

(Mach.), v. 25, no. 3. Nov., 1918, p. 258. LC.(TJ1M21,v.25)

[Organization—Duties—Meetings—First hearing.]

327. GROAT, BENJAMIN F.

Efficiency of the screw. (Eng. S. W. P.), v. 34, no. 5. June, 1918, p. 377-429, incl. diagrs., figs., tables.

Contents.—General considerations.—Notation and remarks thereon—General formulas—Illustrating uses of the formulas and tables—Application to V-threads—Worm gearing—Data of efficiency test of worm-gear drive—Appendix, ''Kingsbury's coefficients.''

328. HARRIS, HARRY E.

The relation of screw-thread angles to other functions. (Am. Mach.), v. 49, no. 18. Oct. 31, 1918, p. 800. 250 words.

Author refers to an article by H. Bingham Powell, under the same title.

. . . ''I would state unreservedly that it is much more expensive to produce the tools for making Whitworth threads than for the simple straight-lined U. S. standard or International form of threads, particularly in loose precision work'' . . .

329. HATTERSLEY, J. F.

Method of expressing tolerances. Letter to editor by J. F. Hattersley, Cleveland, O. (Mach.), v. 25, no. 3. Nov., 1918, p. 254. 450 words. LC.(TJ1M21,v.25)

330. KINGSBURY, ALBERT.

Experiments on the friction of screws. Paper dclxix. (Am. Soc. M. E.), v. xvii, 1896, p. 96-116, incl. figs. 19-21 (half-tone, section, diagrs.), tables i-iv. LC.(TJ1A7,v.17)

With discussion by Prof. R. H. Thurston, W. S. Aldrich, Wm. Kent, J. F. Holloway, O. C. Woolson, Geo. Whitehead, Prof. J. E. Denton, C. L. Newcomb, F. Schuman, C. L. Griffin, Oberlin Smith.

Tables show the "Kingsbury coefficients."

331. MCBRIDE, JAMES.

Some experiments with a screw bolt. Paper ccccl. (Am. Soc. M. E.), v. xii, 1891, p. 781-789, incl. figs. no. 325-327 (diagrs., sections). LC(TJ1A7,v.12)

With discussion by Wilfred Lewis and Arthur A. Falkenau.

332. The National Physical Laboratory in 1917-18, (continued). (Eng.), v. cvi, no.2746. Aug.16, 1918, p.178-180, incl.7 figs.(4 half-tones, 3 sections); no.2747. Aug.23,1918, p.208-211,incl.figs.9-18(half-tones,plan, sections); no.2747. Aug.30,1918,p.221-224,incl.figs.19-32(half-tones,sections, etc.) ES --- LC(TA1E55,v.106)

"Floating-micrometer screw-diameter measuring machine," p. 180—"Screw-pitch measuring machine," p. 208-211—"Horizontal projection apparatus," p. 221-224.

Illustrations: Screw-thread projector, The National Physical Laboratory.—Screw-gauge measuring machines, The N. P. L.

333. NATIONAL PHYSICAL LABORATORY, Teddington.

Notes on screw gauges by the Staff of the gauge testing department. Enlarged issue ii. Nov., 1917. Teddington, W. F. Parrott, [1917] 1 p.l., 50 p., incl. 30 figs. (diagrs., sections, etc.) 34cm. ES.

Contents.—The need for accuracy in a gauge—System of testing screw gauges.—Errors of screws—Pitch—Mechanical measurement of plug screws—Notes on tool and methods of generating thread form—Optical measurements of screw gauges. i. Microscope apparatus. ii. Projection apparatus.—Measurement of ring screw gauges.—Appendices. i. Standard screw threads. ii. Formulae for measurement of effective diameter. iii. Mechanical measurement of angle.

334. OBERG, ERIK.

Developing a gaging system for small area and heavy ordnance. (Mach.), v. 25,no. 2. Oct., 1918, p.93-107,incl.12 figs.(half-tones, diagrs.,etc.), tables. LC(TJ1M21,v.25)

First of a series of articles describing principles involved and procedure followed in developing gaging systems for interchangeable manufacture—Based upon experience of Pratt & Whitney co. in furnishing gaging equipment for small arms and heavy ordnance work.

334a. OBERG, ERIK.

Snap and plug gages. (Mach.), v. 25,no.3. Nov.,1918, p.[194]-200, incl. 24 figs.(half-tones,sections,etc.) LC(TJ1M21,v.25)

Second of a series of articles in continuation of the preceding title.

335. Organization and proceedings of National Screw Thread Commission. (Am.Soc.M.E.), Journal. v.40,no.11. Nov.,1918,p.972-973.

ES --- LC(TJ1A72)v.40

The Commission was cormally appointed by the Sec'y of Commerce on Sept. 21, 1918, and divided up into the following committees: 1. Pitches, systems, form of thread. F. O. Wells, Comdr. E. J. Robinson, E. H. Ehrman, H. T. Herr, H. W. Bearce, sec'y.—2. Tolerances, classification: James Hartness, E. H. Ehrman, Col. E. C. Peck, H. L. Van Keuren, sec'y.—3. Nomenclature and terminology: F. O. Wells, Comdr. E. J. Marquart, Maj. O. B. Zimmermann, Robt. Lacy, sec'y.—4. Gages and methods of test: Col. E. C. Peck,. James Hartness, Comdr. E. J. Marquart, H. L. Van Keuren, sec'y.

As stated in the bill, the duties of the Commission are to ascertain and establish standards for screw threads, which shall be submitted to the Secretary of War, the Secretary of the Navy and the Secretary of Commerce for their approval. These standards when approved, shall be adopted and used in the manufacturing plants under the control of the War and Navy departments and so far as practicable in all specifications for screw threads in proposals for manufactured articles, parts or materials to be used under the direction of these departments.

336. POTTER, M, H.

Machining base plug for 9.2-in.high-explosive howitzer shells. (Mach.), v.25,no.3. Nov.,1918, p.227-228, incl.6 figs.(sections, etc.)

LC(TJ1M21,v.25)

Successive order of operations and machines, tools, and gages used.

337. ROGERS, W. A.

An additional contribution to the perfect screw problem. Paper ccccxlvi. (Am.Soc.M.E.), v. xii, 1891, p.725-728, incl.figs.no.227.

LC(TJ1A7,v.12)

Illustration: Screw-cutting engine built by Webber & Philbrick, Waterville, Me., designed by F. B. Philbrick of that zrm.

338. Screw thread commission organized.

(Soc.Autom.E.) v. iii, no.4. Oct.,1918, p.288. ES. LC.

Record of meeting of Sept. 12, 13, 1918, at Bureau of Standards. It was largely for purpose of organization. Commission consists of: Chairman, Dr. S. W. Stratton, Director, Bureau of Standards. Army representatives: Lt. Col. E. C. Peck, M. S. A. E., Ordnance Dept., U. S. A., and Maj. O. B. Zimmerman, Engineer Corps, U. S. A.—Navy representatives: Comdr. S. M. Robinson, Bureau of Steam Engineering, Navy Dept., and Comdr. E. J. Marquart, Bureau of Ordnance, Navy Dept.

The civilian members will be Edwin H. Ehrman and H. T. Herr, for the S. A. E., and James Hartness and F. O. Wells for the A. S. M. E.

339. SHEAHAN, W. H.

Production problems of aircraft bolts, screws and nuts. (Aviation),v. v.no.6. Oct. 15, 1918, p.363-365, incl. 4 figs.(half-tones).

Author is factory superintendent, A. H. & F. H. Lippincott, Director of the Y. M. C. A. School airplane construction, Director of Aero Club of Philadelphia.

340. Tolerances of fine-screw threads.

(Eng.), v. cvi. Sept.6, 1918, p.268. 520 words. ES -- LC(TA1E55,v.106)

This is a review of the new report no. 84, 1918, of the British Engineering Standards Association on Tolerances of British standard fine (B. S. F.) screw threads, those given in the previous report, no. 38, being thus superseded.

341 Van Keuren, H. L.

The measurement of thread gages. By H. L. Van Keuren, Chief of Gage section, Bureau of Standards,Wash.,D.C. (Am.Soc.M.E.), Journal. v.40,no.11. Nov.,1918, p.913-918,incl. 8 figs.(half-tones).

ES--LC(TJ1A72,v.40)

Contents.—Measurement of plug thread gages—Measurement of pitch— . . . of form and angle of thread— . . . of core diameter— . . . of full diameter—of effective diameter—Choice of wires—Standardization of wires—Computation of effective diameter—Precautions in making three-wire measurements—Test of ring thread gages—Measurement of pitch or lead— . . . of angle and thread form— . . . of full diameter— . . . of core diameter— . . . of effective diameter.

342. Van Keuren, H. L.

Projection lantern for thread measurement by H. L. Keuren and E. C. Griees.(Am.Mach.) v.49, no. 18. Oct.31, 1918, p.805-811, incl. 11 figs (half-tones,sections,etc.)

"The measurement of screw threads presents more kinds of difficulties than almost any other machine part. The apparatus here described has been developed at the Bureau of Standards and is proving very satisfactory, and in common with all developments of the bureau it is free to be used by anyone. The apparatus is easily handled and is well worth careful consideration." 'Synopsis.)

343. Webster, Walter H.

Finding angles of special screw thread. Answered by W. H. Webster, Cincinnati,O. (Mach.), v.25,no.3. Nov.,1918,p.[256] 200 words.

LC(TJ1M21,v.25)

Refers to communication by J. J. Clark in Machinery, July, 1918, p. 1043. See title entry no. 86.

344. Frye, Albert Irvin.

Civil engineers' pocket-book; a reference-book for engineers, contractors- and students, containing rules, data, methods, formulas and tables. N.Y., 1913. ES20500 LC(TA151F8)

345. [Hawkins, Nehemiah.]

Rogers machinists guide; a practical illustrated treatise on modern machine shop practice, by Wm. Rogers [pseud.] N.Y.,c1913.

ES19756 LC(TJ1160H395)

346. Haswell, Charles Haynes.

Mechanics' and engineers' pocket-book of tables, rules, and formulas pertaining to mechanics, mathematics, and physics . . . 68th ed.,N.Y., Harper & bros., 1902. ES2134 LC(TA151H35)

347. Hudson, Ralph Gorton.

The engineers' manual, by Ralph G. Hudson assisted by Jos. Lipka, H. B. Luther and Dean Peabody, jr., N.Y.,1917.

ES24031 LC(TA151H8)

348. Kent, Wm.

The mechanical engineer's pocket-book. A reference-book of rules, tables, data, and formulae, for the use of engineers, mechanics, and students. 8th ed., rewritten. N.Y.,1913 ES21892 LC(TA151K36)

349. Kidder, Frank E.
The architects' and builders' pocketbook . . . by the late Frank E. Kidder . . . compiled by a staff of specialists, Thomas Nolan, editor-in-chief. 16th ed., rewritten, N.Y.,1916. ES22393 LC(TH151K5)

350. Laharpe, Cl. de.
De Laharpe et l'ingénieur et du constructeur-mécancien; mathématiques, mécanique, électricité, chemin de fer, mines, métallurgie, etc., par un comité d'ingénieurs, sous la direction de ch. Vigreux, Ch. Milandre, et R. P. Bouquet. 14e édition, revue, corrigée et consid. augmentée, . . . suivi d'un vocabulaire technique en Française, Anglais, Allemand. Paris, 1905 ES. 3727
The same, 17. édition. Paris, 1913. ES. 19790 LC.(TA151 L2)

351. Lucas, Theodore.
Audels new marine engineers' guide, a practical treatise on marine engines, boilers and auxiliary machinery, . . . By Theo. Lucas and F. D. Graham, N. Hawkins. N. Y., T. Audel & co., c1918.
ES. 24977 LC.(VM600 L94)

352. Machinery.
Machinery's handbook for machine shop and drafting-room; a reference book on machine design and shop practice for the mechanical engineer, draftsman, toolmaker and machinist. N. Y., 1915.
ES. 21879 LC.(TJ151M3)

353. Mackrow, Clement.
The naval architect's and shipbuilder's pocketbook of formulae, rules, and tables and marine engineer's and surveyor's handy book of reference. 8th ed., carefully rev., and enl. N. Y., Lond., 1902.
ES 2191 LC.(VM151M2)

354. Marks, Lionel Simeon, ed.
Mechanical engineers' handbook, based on the "Hütte" and prepared by a staff of specialists, Lionel S. Marks, editor-in-chief. 1st ed., N. Y., 1916. ES. 23400 LC.(TJ151M37)

355. Merriman, Mansfield, editor.
American civil engineers' pocket book; editor-in-chief, M. Merriman; associate editors, Ira O. Baker, A. H. Blanchard [and others]. 1st enl. ed. N. Y., 1912. ES. 20371 LC.(TA151M4)

356. Peirce, Clarence A., comp.
Handbook of formulas and tables for engineers, compiled by C. A. Peirce, with mathematical sections by W. B. Carver. 2d rev., and enl. ed. N. Y., 1916. ES. 24280 LC.(TA151P6

357. Seaton, Albert Edward.
A pocket book of marine engineering rules and tables. . . . 7th rev., and enl. ed., Lond., C. Griffin & co., ltd., N. Y., Van Nostrand co., 1903.
ES. 2099 LC.(VM600 S46)

358. SHIELDS, CHARLES J.

Mechanics' guide, hand book; this hand book contains practical tables for automobile owners, chauffeurs, auto mechanics, engineers, draftsmen, teachers, students, machinists, tool makers, pattern makers, etc. St. Louis, Mo., c1917. ES. 24658 LC.(TJ151S6)

359. SUPLEE, H. H.

The mechanical engineer's reference book. . . . Lond., & Phila., c1913. ES. 20572 LC.(TA151S96)

360. TRAUTWINE, JOHN CRESSON.

The civil engineer's pocket book, by John C. Trautwine . . . rev. by John C. Trautwine, jr., and John C. Trautwine. 3d . . . 19th ed., . . . Phila., 1913. ES. 20075 LC.(TA151T77)

INDEX

TO AUTHORS, TITLES, SUBJECTS, AND TOPICS.

Articles of Engineering Interest.

Compiled with a view to including articles of civil and military engineering subjects of special interest to the readers of PROFESSIONAL MEMOIRS, Corps of Engineers and Engineer Department at Large. By Henry E. Haferkorn, Librarian, Engineer School.

The following abbreviations are used, viz:

Am. Soc. C. E. P.=American Society of Civil Engineers, N.Y. Proceedings.

Am.Soc.C.E.T.=American Society of Civil Engineers, N. Y. Transactions.

A P.C.=Annales des Ponts et Chaussées, Paris.

A. R.=The Army Review, London.

Assoc'n E. S.=Association of Engineering Societies, St. Louis, Mo. Journal.

B.Eng.C.=Brooklyn Engineers' Club, Brooklyn, N. Y. Proceedings.

Ca.E.=Canadian Engineer, Toronto, Can.

Ca.S.E.=Canadian Society of Civil Engineers (Montreal), Transactions.

Cem. E.=Cement Era, Chicago.

Conn.S.C.E.=Connecticut Society of Civil Engineers, New Haven, Conn. Papers and Transactions.

Con.=The Contractor, Chicago.

De Ing.=De Ingenieur Hague, Holland.

Engi.=The Engineer, London.

Eng.=Engineering, London.

Eng.C.=Engineering and Contracting, Chicago.

Eng. M.=Engineering Magazine, N. Y.

Eng. N.=Engineering News, N. Y.

Eng. R.=Engineering Record, N. Y.

Eng.C.P.=Engineers' Club of Phila. Proceedings.

Eng.S.P.=Engineers' Society of Pennsylvania. Harrisburg. Journal.

Eng.S.W.P.=Engineers' Society of Western Penn'a. Pittsburg, Pa. Proceedings.

Inst.C.E.=Institution of Civil Engineers, London. Minutes of Proceedings.

Inst.Eng.Sh.=Institute of Engineers and Shipbuilders in Scotland, Glasgow. Transactions.

Int.R.=Internationale Revue über die gesamten Armeen und Flotten, Dresden.

J.R.Art.=Journal of the Royal Artillery, Woolwich, England.

J.U.S.Art.=Journal, U. S. Artillery, Fort Monroe, Va.

K.T.=Kriegstechnische Zeitschrift, Berlin.

Mu.E.=Municipal Engineering, Indianapolis, Ind.

Prof.M.=Professional Memoirs, Corps of Engineers and Engineer Dept. at Large, U. S. A. Washington.

R.Art.=Revue d'Artillerie, Paris.

Rev.G.=Revue du Génie Militaire, Paris.

R.Eng.J.=Royal Engineers Journal, Chatham, England.

R.U.S.I.J.=Royal United Service Institution, London. Journal.

Sci.Am.=Scientific American, N. Y.

Sci.Am.S.=Scientific American Supplement, N. Y.

Soc.Eng.=Society of Engineers, London. Transactions.

Tech.M.=La Technique Moderne, Paris.

U.S.Nav.I.=U. S. Naval Institute, Annapolis, Md. Proceedings.

W.S.E.J.=Western Society of Engineers, Chicago, Ill. Journal.

(Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 49, Jan.-Feb., 1918.)

ARMAMENT.

Mobile armament for defense. A. M. Coyle. (J. U. S. Art.), July-Aug., 1917. 6000 words, 30 half-tones, 7 diagrs.

ARMORED TRAINS.

Mobile armament for defense. A. M. Coyle. (J. U. S. Art.), July-Aug., 1917. 6000 words, 30 half-tones, 7 diagrs.

ARMY CANTONMENTS.

Camp wastes yield large revenue to the government. Col. Ellison. (Eng. N.), Oct., 18, 1917, 1600 words.

ASPHYXIATING GAS.

Poisonous gas in warfare, Bibliography. H. E. Haferkorn and F. Neumann. (Prof. M.), Nov.-Dec., 1917. p. 758-784., Jan.-Feb., 1918, p. 143-156.

BATTLEFIELD ILLUMINATION.

Battlefield illumination. An example of practice in battlefield illumination in America. R. C. Kuldell. (Prof. M.), Nov.-Dec., 1917. 3528 words, 1 diagr.

CANALS—ITALY.

Le réseau navigable de Milan à l'Adrianople. (LeGénie Civil.), Oct. 20, 1917. 2510 words, map, profile, plan, etc.

CANALS—NETHERLANDS.

Het verslag der Commissie van Advies in zake verbetering van den scheepvaartweg van Amsterdam naar de lek. (De Ing.), Sept. 1, 1917. 2300 words, 1 map.—Het Kanaal naar Twenthe. D. A. Van Heyst. (De Ing.), Oct. 13, 1917. 6400 words, diagrs., 1 large foldmap in colors.

CONCRETE PILES

History and present status of the concrete pile industry. C. R. Gow. (Boston Soc. Civil Eng.), April, 1917. 14000 words, 25 diagrs, 17 half-tones; Discussion, Nov., 1917. 18000 words, 1 diagr. 22 half-tones.

CONCRETE—SEAWATER.

Good workmanship necessary to make seawater concrete safe. R. J. Wig and L. R. Ferguson. (Eng. N.), Oct., 25, 1917, 4800 words, 4 half-tones.

DIKES.

De druk van het buitenwater als oorzaak der verzakkingen van het binnenbeloop der Noord-hollandsche Zuiderzeedijken. J. W. Thierry. (De Ing.), Oct., 13, 1917. 1900 words, diagrs. The pressure of outward water as cause of the sinking of the inner course of the North Holland Zuiderzee dikes.—Mededeelingen befreffende den watersnood van 1916 en zijn gevolgen. Jhr. C. J. A. Reigersman. I. (De Ing.), Oct. 20, 1917. 18900 words; Oct. 27, 1917. 13690 words, illus., plans, maps, diagr.

Communication concerning the flood of 1916 and its consequences.

DREDGES AND DREDGING.

Levee construction and electric pumping for a reclamation project. (Electrical Review), Oct. 20, 1917. 1500 words, 3 half-tones. Sea-going hydraulic hopper dredge for North Pacific bars. G. E. Torney. (Eng. N.), Nov. 8, 1917. 1810 words, 2 half-tones, 1 plan and elevations.

EUROPEAN WAR.

French Engineers span Aisne River under shell fire. R. A. Drake. (Eng. N.), Nov. 29, 1917. 2440 words, 3 half-tones.

FLAME PROJETORS.

Sweeping out captured dugouts with broom of fire. (Sci. Am.), Sept. 8, 1917. 425 words, 1 outline cut, 1 half-tone. Digested in I. M. D., Oct. 1917, p. 575.

FLOODS AND FLOOD CONTROL.

Mededeelingen befreffende den watersnood van 1916 en ziju gevolgen. Jhr. C. J. A. Reigersman. I. (De Ing.), Oct. 20, 1917. 18900 words; Oct. 27, 1917. 13690 words, illus., plans, maps, diagr. Communication concerning the flood of 1916 and its consequences.—Special feature of the Miami Conservancy contracts. (Eng. N.), Oct. 18, 1917. 1900 words, 3 figs, (plans, sections, etc.)

HARBORS—GREAT BRITIAN.

Commercial dock development at Falmouth. (Engi.) Nov. 2, 1917. 1180 words.

HARBORS—NETHERLANDS.

Het verslag der Commissie voor de verbetering en uitbreiding van de haven van Delfzijl. (De Ing.), Sept. 22, 1917. 4830 words, 1 map.

INCENDIARY BOMBS.

Bombe incendiarie e bombe esplosive tedesche do oerei. (Rivista di Artiglieria). July-Aug., 1917, 1600 words, 2 outline figs.

INLAND NAVIGATION.

Het verslag der Commissie van Advies in zake verbertering van den scheepvaartweg van Amsterdam naar de lek. (De Ing.), Sept. 1, 1917. 2300 words, 1 map.

INTRENCHMENTS.

Organization and duties for trench fighting. O. N. Solbert and G. Bertrand. (Prof. M.), Nov-Dec., 1917. 17640 words, 19 diagr.

LEVEES.

Levee construction and electric pumping for a reclamation project. (Electrical Review.), Oct. 20, 1917. 1500 words, 3 half-tones.

MEXICO—PUNITIVE EXPEDITION, U. S. 1916.

Road work on the punitive expedition into Mexico. E. Graves. (Prof. M.), Nov.-Dec., 1917. 10584 words, 4 cross sections, 1 map.

MILITARY BRIDGES.

Fighting Flanders mud and the Germans. (Sci. Am.), Nov. 10, 1917. 920 words, 4 half-tones.—French Engineers span Aisne River under shell fire. R. A. Drake. (Eng. N.), Nov., 29, 1917. 2440 words, 3 half-tones.

MILITARY ROADS—SEE ALSO MEXICO.

Military roads on the island of Oahu. W. E. R. Covell. (Prof. M.), Nov-Dec., 1917. 3024 words, 13 half-tones, 3 temperature charts.

Road work on the punitive expedition into Mexico. E. Graves (Prof. M.), Nov.-Dec., 1917. 10584 words, 4 cross-sections, 1 map.

MOTOR TRUCKS.

Coal gas for motor vehicles. (Sci. Am. S.), Nov. 10, 1917. 2170 words, 3 half-tones. Design of new military truck. (Am. Machinist.), Oct. 18, 1917.

700 words. History's lesson to the motor truck. (Sci. Am.), Nov. 10, 1917. 1832 words, 5 half-tones. Mobile armament for defense. A. M. Coyle. (J. U. S. Art.), July-Aug., 1917. 600 words, 30 half-tones, 7 diagr. How motor trucks saved Verdun. W. F. Bradley. Motor Age, Chicago. v. xxxii, No. 3, July 19, 1917, p. 5-11, incl. maps, illus. Army War College. Library. Monthly List, Sept. 1917, item 210. Lessons of the war in truck design. W. O. Thomas. Society of Automotive Engineers, inc., N. Y. Journal. v. i, No. 1. July, 1917, p. 23-31, incl. illus. Army War College. Library. Monthly List. Sept. 1917, item 209.

ORDNANCE.

Le serrage mécanique des chaupeaux sur les têtes d'obus. Le Génie Civil, Oct. 20, 1917. 700 words. Mobile armament for defense. A. M. Coyle. (J. U. S. Art.), July-Aug., 1917. 6000 words. 30 half-tones. 7 diagrs.

PANORAMIC SIGHTS.

The panoramic sight. W. L. Olmstead. v. Assembling operations. (Am. Mach.), Oct. 25, 1917. 4 half-tones, 7 outline cuts (sections, etc.). 4500 words; vi. Nov. 15, 1917. 5580 words. 11 half-tones, 5 outline cuts.

POISONOUS GAS.

Poisonous gas in warfare. Bibliography. H. E. Haferkon and F. Neumann. (Prof. M.), Nov.-Dec., 1917, p. 758-784; Supplementary references. H. E. Haferkorn. (Prof. M.), Jan.-Feb., 1918. Our earliest cannon, 1314-1346. Lt. Col. H. W. L. Hime. (Royal Art. Inst., Woolwich, Eng. Proceedings), v. 31, No. 12, p. [489]—494, incl. diagrs. with bibliographical footnotes.

RIFLES, AUTOMATIC.

The Madsen and Bergmann, 1915 models of automatic rifles used by the German infantry. (From reliable sources). Prof. M., Nov.-Dec., 1917. 120 words. 2 diagrs.

SALVAGE.

A new device for raising sunken ships. (Engi.) Nov. 2, 1917. 850 words. 4 half-tones.

SEARCHLIGHTS.

An example of practice in battlefield illumination in America. R. C. Kuldell. Prof. M.), Nov.-Dec., 1917. 3528 words. 1 diagr. Les projecteurs de campagne. Manuel technique et tactique à l'usage des chefs d'équipe et des officers observateurs. Janvier, 1917. Par Gaston Breton. Paris, H. C. Lavauzelle, [1917]. 379 p. illus., diagrs. etc. 19cm. Army War College, Library. UG626. B84.

SEAWATER—CONCRETE.

Selection of materials for seawater concrete. R. J. Wig and L. R. Ferguson, (Eng.N.), Oct. 18, 1917. 3600 words. 5 half-tones.

STAR SHELLS.

Proyectiles iluminantes y el combate nocturno. Clemente Casciani. Revista Militar, Buenos Aires, Arg. Rep. año xvi, No. 291. Abril, 1917, p. 282-298, incl., outline cuts. Army War College Library. Monthly List. Sept. 1917, item 278.

STREAM CROSSING.

Fighting Flanders mud and the Germans. (Sci Am.), Nov. 10, 1917. 920 words, 4 half-tones.

SUBSISTENCE DEPT.—FRANCE.

How France subsists her armies at the front. Tr. Col. W. R. Livermore. (Prof. M.), Nov.-Dec., 1917. 4716 words. 7 half-tones, 1 diagr.

TRACTORS, MILITARY.

Mobile armament for defense. A. M. Coyle. (J. U. S. Art.), July-Aug., 1917. 6000 words. 30 half-tones, 7 diagrs. Care and operation of the "caterpillar" 45 tractor. The Holt Mfg. Co. inc., Stockton, Cal., Peoria, Ill., 1917. illus., fold. Plates. The crawling tractor fifty years ago. (Sci. Am.), Nov. 24, 1917. 1 fig. 800 words. (Shows drawings of the Lake crawler of 1867). Dion, S. A. Tanks, gas, bombing, liquid fire. N. Y., Geo. U. Harvey, 1917. The evolution of the chain-track tractor. vii. (Engi.), v. 124, No. 3221, Sept. 21, p. 241-244, 1917. Figs. 68-84. 5000 words.

Fig. 68. Diplock chain-track tractor, 1912. Fig. 69. Sprocket wheel and chain of feet. Diplock, 1912. Fig. 70. Section, etc., of arrangement of feet and feet carriers. Diplock vehicle, 1912. Figs. 71, 72. Arrangement of roller-chains. Diplock vehicle, 1912. Fig. 73. The Diplock chain-track, 1913. Fig. 74. Foot and foot carrier, Diplock chain-track, 1913. Fig. 75. Diplock chain-tractor. Fig. 77. The Holt agricultural chain-track tractor, 1911. Fig 78. Diplock chain-track, 1911. Fig 79. Diplock chain-track vehicle, 1911-12. Fig. 80. Diplock chain-track lorry, 1912. Fig. 81. Diplock chain-track tractor, 1913. Figs. 82, 83. Diplock one-ton chain-track wagon, present day. Fig. 84. Lombard agricultural chain-track petrol tractor, present day.

Traction mécanique et motoculture. Expériences récentes de labourage mécanique. La Nature, Paris. v. 43. 2e semestre, No. 2195. 23 oct., 1915, p. 257-263. 7 illus. (Signed B. et L.). The British tank and the man who suggested it. American Machinist, N. Y. v. 47, No. 23. Dec. 6, 1917, p. 1010-11 2 half-tones.

Illustrations: 1. A Tank. 2. Portrait of Col. E. D. Swinton.

Americans man French motor transport service. W. F. Bradley. Motor Age, Chicago. v. xxxii. Aug. 2, 1917, p. 18-22, incl. illus. Army War ollege. Library Monthly List, Sept., 1917, item 293. The caterpillar tractor. Machinery, N. Y. v. xxiii, No. 12, Aug., 1917, p. 1041-1046, incl. illus. Army War College. Library. Monthly List, Sept. 1917, item 286. The "tanks." The powerful armed, bullet-proof engine of death and destruction that has been developed by England for use in the war from the invention of an American. Col. E. D. Swinton, R. E. World's Work, Garden City, N. Y. v. xxxiv, No. 5. Sept., 1917, p. 569-571, incl. 1 illus. Army War College. Library Monthly List, Oct., 1917, item 285; 302. Tractors for hauling artillery. W. F. Bradley. Motor Age, Chicago. v. xxxii, Aug. 23, 1917, p. 20-23, incl. illus. Army War College. Library. Monthly List, Oct., 1917, item 317.

TRENCH WARFARE.

Organization and duties for trench fighting. O. N. Solbert and G. Bertrand. (Prof. M.), Nov.-Dec., 1917. 17640 words. 19 diagrs.

TRENCHING MACHINES.

Some experiences with a trenching machine. G. W. Batchelder. (New England Water Works Assoc'n. Journal), Sept., 1917. 2450 words.

Erratum

On page 21, line 5, instead of Colonel, read Major; on line 6, after Corps of Engineers, read Lieutenant Colonel Engineers, National Army.

Articles of Engineering Interest.

Compiled with a view to including articles of civil and military engineering subjects of special interest to the readers of PROFESSIONAL MEMOIRS, Corps of Engineers and Engineer Department at Large. By Henry E. Haferkorn, Librarian, Engineer School.

The following abbreviations are used, viz:

Am. Soc. C. E. P.=American Society of Civil Engineers, N.Y. Proceedings.

Am.Soc.C.E.T.=American Society of Civil Engineers, N. Y. Transactions.

A P.C.=Annales des Ponts et Chaussées, Paris.

A. R.=The Army Review, London.

Assoc'n E. S.=Association of Engineering Societies, St. Louis, Mo. Journal.

B.Eng.C.=Brooklyn Engineers' Club, Brooklyn, N. Y. Proceedings.

Ca.E.=Canadian Engineer, Toronto, Can.

Ca.S.E.=Canadian Society of Civil Engineers (Montreal), Transactions.

Cem. E.=Cement Era, Chicago.

Conn.S.C.E.=Connecticut Society of Civil Engineers, New Haven, Conn. Papers and Transactions.

Con.=The Contractor, Chicago.

De Ing.=De Ingenieur Hague, Holland.

Engi.=The Engineer, London.

Eng.=Engineering, London.

Eng.C.=Engineering and Contracting, Chicago.

Eng. M.=Engineering Magazine, N. Y.

Eng. N.=Engineering News, N. Y.

Eng. R.=Engineering Record, N. Y.

Eng.C.P.=Engineers' Club of Phila. Proceedings.

Eng.S.P.=Engineers' Society of Pennsylvania. Harrisburg. Journal.

Eng.S.W.P.=Engineers' Society of Western Penn'a. Pittsburg, Pa. Proceedings.

Inst.C.E.=Institution of Civil Engineers, London. Minutes of Proceedings.

Inst.Eng.Sh.=Institute of Engineers and Shipbuilders in Scotland, Glasgow. Transactions.

Int.R.=Internationale Revue über die gesamten Armeen und Flotten, Dresden.

J.R.Art.=Journal of the Royal Artillery, Woolwich, England.

J.U.S.Art.=Journal, U. S. Artillery, Fort Monroe, Va.

K.T.=Kriegstechnische Zeitschrift, Berlin.

Mu.E.=Municipal Engineering, Indianapolis, Ind.

Prof.M.=Professional Memoirs, Corps of Engineers and Engineer Dept. at Large, U. S. A. Washington.

R.Art.=Revue d'Artillerie, Paris.

Rev.G.=Revue du Génie Militaire, Paris.

R.Eng.J.=Royal Engineers Journal, Chatham, England.

R.U.S.I.J.=Royal United Service Institution, London. Journal.

Sci.Am.=Scientific American, N. Y.

Sci.Am.S.=Scientific American Supplement, N. Y.

Soc.Eng.=Society of Engineers, London. Transactions.

Tech.M.=La Technique Moderne, Paris.

U.S.Nav.I.=U. S. Naval Institute, Annapolis, Md. Proceedings.

W.S.E.J.=Western Society of Engineers, Chicago, Ill. Journal.

(Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 50, March-April, 1918.)

AEROPLANES, ARMAMENT OF.

Armament of aeroplanes. (Eng.), Nov. 23, 1917. 1503 words. 22 outline figs., 2 half-tones.

AERIAL PHOTOGRAPHY.

How the aerial photographer snaps his views. (Sci. Am.), Jan. 26, 1918. 130 words. Front., 1 half-tone.

AERIAL WARFARE.

Theory of bomb dropping. E. Hemkel. Trans. by E. L. Gayhart. (Aviation), Jan. 15, 1918. 1890 words. 11 diagrs.

ARMOR.

Cuirasses, casques et boucliers. Nic. Flamel. (Le Génie Civil), Sept. 15, 1917. 5600 words. 5 half-tones, 3 cross-sections.

ASPHYXIATING GAS.

Shells that burn and suffocate. (Popular Science Monthly, N. Y.), v. 92, No. 2, Feb., 1918, p. 203. 400 words.

AUTOMOTIVE ENGINEERING.

Automotives in the great war. C. F. Clarkson. (Sci. Am. S.), Jan. 26, 1918. 3500 words. The same in Am. Machinist, Jan. 24, 1918.

BALLISTICS.

On accuracy of firing with oblique fire. A. M. Grundy. (J. R. Art.), Oct., 1917. 1716 words. 2 diagrs.

BLOCKHOUSES—MILITARY.

The trench system of defense vs. the pill box system. (Sci. Am.), Dec. 22, 1917. 1032 words. 1 half-tone.

BOMB-PROOF SHELTERS.

Deep gallery shelters. Col. P. S. Bond and Lieut. R. D. Leisk. (Prof. M.), Jan.-Feb., 1918. 3528 words. 3 cross-sections.—Use of corrugated iron for construction of shelters. Tr. by Maj. Henry Swift. (Prof. M.), Jan.-Feb., 1918. 3660 words. 6 plans. 2 cross-sections.

BREAKWATERS.

Construction of rubble mound extension to breakwater at Marquette, Mich. C. Coleman. (Prof. M.), Jan.-Feb., 1918. 6500 words. 11 half-tones. 1 diagr. 2 maps.

BUILDING CONSTRUCTION.

What is mill building construction? (Eng. N.), Dec. 27, 1917. 5910 words. 2 plans, elevations, cross-sections, etc.

BUILDING CONSTRUCTION. (FRAMING. See FRAMING).

CAISSONS.

Caissons and cribs for lighthouse foundations. (Eng. N.), Jan. 10, 1918. 2350 words. 2 half-tones, cross-sections, plans, etc.

CAMOUFLAGE.

Striped suits and papier maché carcasses as camouflage. (Sci. Am.), Jan. 28, 1918. 270 words. 2 half-tones.

CAMP CONSTRUCTION.

Portable units form buildings for labor camps. (Eng. N.), Jan. 17, 1918. 650 words. 2 half-tones. 2 plans, cross-sections, elevations, etc.

CANALS—FRANCE.

Travaux d' après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Genie Civil), Dec. 8, 1917. 6580 words.

CANALS—GREAT BRITAIN.

Canals. Editorial. (Engi.), Nov. 23, 1917. 2565 words—Mid-Scotland ship canal schemes. (Engi.), Nov. 30, 1917. 3690 words. 3 maps. 1 section.

CANALS—NETHERLANDS.

Het Kanaal naar Twenthe. D. A. Van Heyst. (De Ing.), Oct. 13, 1917. 6400 words. diagrs. 1 large fold. map in colors.

CANALS—UNITED STATES.

The Barge Canal a vital war factor. (Barge Canal Bull.), Nov., 1917. 1320 words.—New York State barge canal. D. B. La Du. (Sci. Am.), Jan. 12, 1918. 2032 words. 6 half-tones. 1 map and profiles.

CEMENT—CONCRETE.

The Marine use of concrete. (Sci. Am.), Jan. 26, 1918. 1600 words. 3 half-tones.—Spalling of reinforced concrete in moist location. (Eng. N.), Jan. 3, 1918. 830 words. 2 half-tones.

CONCRETE—SEAWATER.

Does waterproof concrete resist sea water? R. J. Wig, L. R. Ferguson, Toch Bros. (Eng. N.), Dec. 27, 1917. 1160 words.

CONCRETE SHIPS.

Concrete ship building firmly established by Norwegian firm. (Eng. N.), Dec. 13, 1917. 2210 words. 3 half-tones. 5 diagrs.—Ferro-concrete motor-ship and dock. (Eng.), Dec. 14th, 1917. 600 words. 1 half-tone.—First large concrete ship building at San Francisco. (Eng. N.), Jan. 17, 1918. 360 words. 13 half-tones.—Joint committee on concrete ships makes a report. (Eng. N.), Dec. 13, 1917. 2520 words.—The Marine use of concrete. (Sci. Am.), Jan. 26, 1918. 1600 words. 3 half-tones.—Reinforced concrete ship-building in Norway. (Engi.), Dec. 14, 1917. 890 words.—Sea-going ships of concrete. (Concrete), Dec., 1917. 300 words. 6 half-tones.

CONCRETE TOWERS.

Traveling towers place 92,000 yards of concrete. (Eng. N.), Jan. 10, 1918. 3790 words. 3 half-tones. 2 cross-sections. 1 diagr.

CRANES, HOISTS, ETC.

Development of air hoists. (Am. Machinist), Jan. 24, 1918. 1171 words.—Hoisting machinery that is helping to win the war. (Am. Machinist), Jan. 24, 1918. 300 words. 3 half-tones.

CRIBS.

Test of long-submerged hemlock timber. T. R. Lawson. (Eng. N.), Jan. 28, 1915. 365 words. 1 half-tone. Illustrations:—Hemlock stick in testing machine after 40 years submersion.—Caissons and cribs for light-house foundations. (Eng. N.), Jan. 10, 1918. 2350 words. 2 half-tones, cross-section, plans, etc.

DAMS.

Engineering practice and construction work on Upper Mississippi River. (Engineering and Cement World), Jan. 15, 1918. 5048 words. 5 half-tones.—

Floating-crest gates used on Sherburne Lakes dam. (Eng. N.), Jan. 17, 1918. 1560 words. 1 cross-section. 1 diagr.

DREDGES AND DREDGING.

Dipper dredgers on the Panama canal. R. W. Berdeau, jr. (Eng.), Nov. 16, 1917. 2792 words. 1 fold. plate.—Home-made dredge reduces cost of canal construction. (Eng. N.), Dec. 26, 1917. 650 words. 2 half-tones.

ELEVATORS.

Operation and maintenance of elevators-winding-drum machines. R. H. Whitehead. (Power), Jan. 8, 1918. 2259 words. 6 half-tones, 1 cross-section, 1 diagram.

ENGINEER TROOPS.

Liaison of divisional engineers with the other troops. Major Rousseau, (Prof. M.), Jan-Feb. 1918. 5000 words.

ENGINEER TROOPS-EQUIPMENT.

Supply organization expands 2250 per cent to equip Engineer troops. (Eng. N.), Jan. 3, 1918. 3000 words. 1 table.

EXPLOSIVES.

Nitrates in war and peace. (Eng.), Nov. 30, 1917. 1880 words. The nitrogen problem. ommunicated by the Ministry of munitions (England). (Engi.), Nov. 30, 1917. 1107 words.

FORTIFICATIONS, FIELD.

Report on the defense of Gominecourt on July 1, 1916. (R. U. S. I. J.) Aug. 1917. 9000 words. 6 sketch maps. Digested in I. M. D., Nov. 1917. p. 620.

FREIGHT HANDLING.

L'Installation pour le chargement du charbon du port de Durban, Afrique du Sud. (Le Génie Civil), Oct. 20, 1917. 2550 words. 3 half-tones, plan, elevation, cross-section, etc.

HELMETS.

Cuirasses, casques et boucliers. Nic. Flamel. (Le Génie Civil), Sept. 15, 1917. 5600 words. 5 half-tones, 3 cross sections.

HARBORS—Equipment. See under FREIGHT HANDLING.

HARBORS—FRANCE.

Les ports français et la guerre. Ports secondaires et complémentaires. A. Pawlowski. (Le Génie Civil), Sept. 22, 1917. 3200 words. 3 half-tones, 3 tables, 5 plans. Les ports français et la guerre. Situation d'ensemble et conclusions générales. A. Pawlowski. (Le Génie Civil), Nov. 24, 1917. 3970 words. Travaux d'après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil), Dec. 1, 1917; Dec. 8, 1917. 2789 and 3800 words.

HARBORS—GREAT BRITAIN.

Harbour improvement for imperial trade. (Eng.), Dec. 7, 1917. 1800 words. Port development at Plymouth. (Engi.), Dec. 7, 1917. 440 words.

HARBORS—SOUTH AMERICA.

Havenplannen in Peru. (De Ing.), Dec. 8, 1917. 2560 words. 1 map.

HOISTING MACHINERY.

Operation and maintenance of elevators, winding-drum machines. R. H. Whitehead. (Power), Jan. 8, 1918. 2259 words. 6 half-tones, 1 cross-section, 1 diagr.

HORSES.

Horsewater troughs and horsewater points. Capt. H. S. Briggs. (R. Eng. J.), Dec. 1917. 627 words. 3 sections, etc. Practical horsemastership in the field. (J. R. Art.), Oct. 1917. 9900 words.

HORSEWATER TROUGHS. See HORSES.

HYDRAULIC ENGINEERING.

Travaux d'après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil), Dec. 1, 1917; Dec. 8, 1917. 2780 and 3800 words.

INLAND NAVIGATION.

Activity in river transportation developed in 1917. (Eng. N.), Dec. 27, 1917. 1680 words. The commercial waterways of the United States. Col. J. Millis. (Prof. M.), Jan.-Feb., 1918. 3024 words. The need for the use of our interior waterways. (Commerce Reports), June 13, 1917. 1800 words. Progress in inland waterways development. (Eng. C.), Jan. 9, 1918. 710 words. Le réseau navigable de Milan à l'Adrianople. A. Goupil. (Le Génie Civil), Oct. 20, 1917. 2590 words. Map, plan, profiles, etc.

JETTIES.

Precast units for sea wall construction. Timber jetties at Avon, N. J., replaced by hollow concrete piles and rip-rap. (Concrete), Dec., 1917. 700 words. 4 diagrs.

LAUNDRIES.

Notes on a divisional laundry. apt. R. E. Stradling. (R. Eng. J.), Dec., 1917. 1328 words. 14 plans, sections, etc.

LIAISON.

Liaison of divisional engineers with other troops. Major Rousseau. (Prof. M.), Jan.-Feb., 1918. 5000 words.

LOCKS AND LOCK GATES.

Engineering practice and construction work on Upper Mississippi River. (Engineering and Cement World), Jan. 15, 1918. 5048 words. 5 half-tones

LOCOMOTIVES, OIL-BURNING.

The ''Ruston'' oil-engined locomotive. (Eng.), Nov. 30, 1917. 1275 words. 1 half-tone, 1 diagr.

MAXIM GUN. See ARMAMENT OF AEROPLANES.

MILITARY MINES.

Mining operations, especially for infantry. Trans. by Col. W. R. Livermore. (Prof. M.), Jan.-Feb., 1918. 5550 words. 7 diagrs, 12 cross-sections.

MILITARY RAILROADS.

American locomotives for the American forces in France. (Engi.), Nov. 23, 1917. 600 words. 1 half-tone. Locomotives et wagons des chemins de fer militaires américains en France. (Le Génie Civil), Dec. 8, 1917. 380 words. Rail and motor transport as applied to military operations. Col. P. S. Bond. (Prof. M.), Jan.-Feb., 1918. 7500 words.

MILITARY ROADS.

Military and other highways in war time. W. D. Sohier. (Eng. N.), Dec. 13, 1917. 9000 words.—Military roads. Col. W. D. Sohier. (Eng. C.), Jan. 2, 1918. 2500 words.

MILITARY TRANSPORTATION.

Army transportation. (Am. Soc. Mech. Eng.), Journal. Jan., 1918. 700

words. 3 half-tones. Rail and motor transport as applied to military operations. Col. P. S. Bond. (Prof. M.), Jan.-Feb., 1918. 7500 words.

MOTOR CARS AND TRUCKS.

How motor trucks saved Verdun. W. F. Bradley. Motor Age, Chicago. v. 32, no. 3. July 19, 1917. p. 5-11, incl. maps. illus. Army War College. Monthly List. Sept., 1917, item 210.—Lessons of the war in truck design. W. O. Thomas. Society of Automotive Engineers, inc., N. Y. Journal, v. i, July, 1917. p. 23-31, incl. illus. Army War College. Monthly List. Sept., 1917, item 209.—Looking forward. The place of the automobile in the years to come. J. R. Eustis. (Sci. Am.), Jan. 5, 1918. 2360 words. 2 half-tones. Motor trucks transportation. W. P. Kennedy. (Am. Soc. Mech. Eng.) Journal. Jan., 1918. 2610 words. 1 half-tone.—New steam motor truck. (Sci. Am.), Dec. 15, 1917. 1784 words. 2 half-tones. Six-ton steam wagon. Atkinson & Co., Preston, England. (Engi.), Dec. 7, 1917. 2360 words, 3 half-tones, 9 plans, 1 elevation.—Rail and motor transport as applied to military operations. Col. P. S. Bond. (Prof. M.), Jan.-Feb., 1918. 7500 words.

MUD TOBOGGANS.

Mud toboggan to carry one stretcher or 200 lbs. Maj. A. C. Finnimore. (R. Eng. J.), Nov., 1917. 360 words. 1 plan, 2 sections.

NAILS.

The holding power of nails. Lieut. J. M. H. Goodwin. (R. Eng. J.), Dec., 1917. 1100 words. 4 diagrs.

OCEAN TERMINALS.

New ocean freight terminal started on Staten Island. (Eng. N.), Jan. 17, 1918. 2590 words. Plans, elevation, cross-sections.

PANAMA CANAL. See also PIERS.

Dipper dredgers on the Panama canal. R. W. Berdeau, jr. (Eng.), Nov. 16, 1917. 2792 words. 1 fold. Plate.

PARABELLUM MACHINE GUN. See ARMAMENT OF AEROPLANES.

PIERS.

Methods and cost of constructing reinforced concrete pier shells for Balboa docks. R. Z. Kirkpatrick. (Eng. C.), Jan. 16, 1918. 976 words. Plans, cross-sections, diagrs, etc. Test of long-submerged hemlock timber. T. R. Lawson. (Eng. N.), Jan. 28, 1915. 369 words. 1 half-tone. Illustration: Hemlock stick in testing machine after 40 years submersion.

PILES AND PILING.

Wharf has combination timber and concrete piles. (Eng. N.), Dec. 13, 1917. 650 words. 11 elevations, plans, etc.

RAIDS.

German raid on British trenches. Trans. from captured German documents. (Infantry Journal), Sept., 1917. 10000 words. 4 sketches, 3 tables. See also I. M. D., Nov., 1917. p. 632.

RIVER ENGINEERING. See also MISSISSIPPI RIVER—UPPER MISSISSIPPI.

Kaukakee River is improved for drainage of marshes. (Eng. N.), Dec., 27, 1917. 900 words. 1 half-tone, 1 cross-section. Travaux d'après guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil), Dec. 1, 1917; Dec. 8, 1917. 2780 and 3800 words.

RUSSIA.

Russia—an opportunity for American engineers. G. C. Whipple. (Boston Soc. Civil Eng.), Dec., 1917. 2892 words.

RUSSO-JAPANESE WAR.

Use of the general reserve in grand tactic maneuvers as illustrated in the Russo-Japanese war. Maj. W. A. Mitchell. (Prof. M.), Jan.-Feb., 1918. 12000 words. 13 maps.

SEARCHLIGHTS.

Advanced base searchlights. Maj. H. C. Judson. (Marine Corps Gazette.) Dec., 1917. 5720 words. 2 half-tones, 6 diagrs.—Government needs men for searchlight regiment. (Electrical Review). Jan. 19, 1918. 620 words. 1 half-tone. The same, Electrical World. Jan. 19, 1918. 620 words. 1 half-tone.—Signaling to and from aircraft by means of miniature searchlights. (Sci. Am.), Sept. 29, 1917. 160 words. See also, I. M. D., Nov., 1917. p. 636.

SEAWALLS.

Precast units for sea wall construction. Timber jetties at Avon, N. J., replaced by hollow concrete piles and rip-rap. (Concrete.) Dec., 1917. 700 words. 4 diagrs.

SIGNALING, VISUAL.

Signaling to and from aircraft by means of miniature searchlights. (Sci. Am.), Sept. 29, 1917. 160 words. See also I. M. D., Nov., 1917. p. 636.

STAR SHELLS.

Projectiles iluminantes y el combate nocturno. Clemente Casciahi. Revista Militar, Buenos Aires, Arg. Rep., año xvi, no. 291, abril, 1917, p. 282-298, incl. illus., outline cuts. Army War College. Monthly List. Sept., 1917. Item 278.

STRATEGY.

Use of the general reserve in grand tactic maneuvers as illustrated in the Russo-Japanese war. Maj. W. A. Mitchell. (Prof. M.), Jan.-Feb., 1918. 12000 words. 13 maps.

SUBMARINES.

Prisoner's experience aboard U-Boat. (U. S. Nav. I.), Aug., 1917. p. 1881-1886. 21500 words. 1 diagr. (Will be continued.)—The submarine. Modern development of an old invention. M. F. Hay. (Sci. Am. S.), Jan. 26, 1918. 5200 words.

"TANKS"—See TRACTORS, MILITARY.

TARGET FRAMES.

Rifle range target frame windmill pattern. Lt. Col. A. A. Crookshank. (R. Eng. J.), Nov., 1917. 1150 words. 1 plan, 3 sections.

TEAR SHELLS.

Shells that burn and suffocate. (Popular Science Monthly), v. 92, no. 2, Feb., 1918, p. 203. 400 words. See also Bibliography: Poisonous Gas in Warfare in Prof. M., nos. 48 and 49.

TIMBER TESTS.

Test of long-submerged hemlock timber. T. R. Lawson. (Eng. No), Jan. 28, 1915. 369 words. 1 half-tone. Illustration: Hemlock stick in testing machine after 40 years submersion.

TORPEDOES.

Les modèles actuels de torpilles automobiles. Strob. (Le Génie Civil),

Dec. 8, 1917. 4450 words. 10 half-tones, 1 elevation, plan, cross-sections, etc.

TRACTORS, MILITARY.

Americans man French motor transport service. W. F. Bradley. Motor Age, Chicago, v. 32, Aug. 2, 1917, p. 18-22, incl. illus. Army War College. Monthly List, Sept., 1917, item 293.—British and French tanks. (Sci. Am.), v. cxviii, no. 3, Jan. 19, 1918, p. 68. 570 words. 7 half-tones.

Illustrations: 1. Tank hauling back to British lines a German gun, captured in Cambrai drive. Note the camouflage. 2. One of the captured heavy German field guns, towed home by its captor. 3. French tank, camouflage. Note canvas on roof, which is let down to conceal tank, when at rest. 4. Interior of French tank, showing breach and trail of French "75" mm. field gun. 5. French tank with one "75" mm. gun and four machine guns. 6. Two views of British tank: "Britannia" giving demonstration at Camp Upton.

The caterpillar tractor. Machinery, N. Y., v. 23, no. 12, Aug., 1917, p. 1041-1046, incl. illus. Frontispiece, p. 1039. Army War College. Monthly List, Sept., 1917, item 286.—Gasoline horses which will haul our artillery in the field. (Sci. Am.), Dec. 15, 1917. 176 words. 2 half-tones.—Some British agricultural tractors and haulers. i. (Engi.), Dec. 14, 1917. 3480 words.—The ''Tanks.'' The powerful, armed, bullet-proof engine of death and destruction that has been developed by England for use in the war from the invention of an American. By Col. E. D. Swinton, R. E. World's Work, Garden City, N. Y., v. 34, no. 5, Sept., 1917, p. 569-571, incl. illus. Army War College. Monthly List, Oct., 1917, item 285; 302.—Tractors for hauling artillery. W. F. Bradley. Motor Age, Chicago, v. 32, Aug. 23, 1917, p. 20-23. illus. Army War College. Monthly List, Oct., 1917, item 317.

TRAVELING TOWERS. See CONCRETE TOWERS.

TRENCH WARFARE.

Description of a battle trench pumping outfit. Lieut. W. A. Edwards, U. S. N. (U. S. Nav. I.), Dec., 1917. 1200 words. 2 half-tones, 2 cross-sections.—German raid on British trenches. Trans. from captured German documents. (Infantry Journal), Sept., 1917. 10000 words. 4 sketches, 3 tables. See also I. M. D., Nov., 1917, p. 632.—Organization and duties for trench fighting. Capts. O. N. Solbert and G. Bertrand. (Prof. M.), Jan.-Feb., 1918. 4000 words.

TROUGHS (HORSEWATERING). See HORSES.

UPPER MISSISSIPPI RIVER.

Engineering practice and construction work on Upper Mississippi River. (Engineering and Cement World), Jan. 15, 1918. 5048 words. 5 half-tones.

WATER SUPPLY.

Water-supply specifications for National Army cantonments reviewed. (Eng. N.), Jan. 3, 1918. 2860 words.

WATER TRANSPORTATION.

Activity in river transportation developed in 1917. (Eng. N.), Dec. 27, 1917. 1680 words.—The need for use of our interior waterways. (Commerce Reports), June 13, 1917. 1800 words.

WHARVES.

Methods and cost of constructing reinforced concrete pier shells for Balboa docks. R. Z. Kirkpatrick. (Eng. C.), Jan. 16, 1918. 976 words. plans, cross-sections, diagrs., etc.—Wharf has combination timber and concrete piles. (Eng. N.), Dec. 13, 1917. 650 words. 11 elevations, plans, etc.

WIRE ROPES.

Wire ropes. By ''Kinetic.'' (Practical Engineer, London), Jan. 3, 1918. 1200 words. 4 diagrs., 1 cross-section.

Articles of Engineering Interest.

Compiled with a view to including articles of civil and military engineering subjects of special interest to the readers of PROFESSIONAL MEMOIRS, Corps of Engineers and Engineer Department at Large. By Henry E. Haferkorn, Librarian, Engineer School.

The following abbreviations are used, viz:

Am. Soc. C. E. P.=American Society of Civil Engineers, N.Y. Proceedings.

Am.Soc.C.E.T.=American Society of Civil Engineers, N. Y. Transactions.

A.P.C.=Annales des Ponts et Chaussées, Paris.

A. R.=The Army Review, London.

Assoc'n E. S.=Association of Engineering Societies, St. Louis, Mo. Journal.

B.Eng.C.=Brooklyn Engineers' Club, Brooklyn, N. Y. Proceedings.

Ca.E.=Canadian Engineer, Toronto, Can.

Ca.S.E.=Canadian Society of Civil Engineers (Montreal), Transactions.

Cem. E.=Cement Era, Chicago.

Conn.S.C.E.=Connecticut Society of Civil Engineers, New Haven, Conn. Papers and Transactions.

Con.=The Contractor, Chicago.

De Ing.=De Ingenieur Hague, Holland.

Engi.=The Engineer, London.

Eng.=Engineering, London.

Eng.C.=Engineering and Contracting, Chicago.

Eng. M.=Engineering Magazine, N. Y.

Eng. N.=Engineering News, N. Y.

Eng. R.=Engineering Record, N. Y.

Eng.C.P.=Engineers' Club of Phila. Proceedings.

Eng.S.P.=Engineers' Society of Pennsylvania. Harrisburg. Journal.

Eng.S.W.P.=Engineers' Society of Western Penn'a. Pittsburg, Pa. Proceedings.

Inst.C.E.=Institution of Civil Engineers, London. Minutes of Proceedings.

Inst.Eng.Sh.=Institute of Engineers and Shipbuilders in Scotland, Glasgow. Transactions.

Int.R.=Internationale Revue über die gesamten Armeen und Flotten, Dresden.

J.R.Art.=Journal of the Royal Artillery, Woolwich, England.

J.U.S.Art.=Journal, U. S. Artillery, Fort Monroe, Va.

K.T.=Kriegstechnische Zeitschrift, Berlin.

Mu.E.=Municipal Engineering, Indianapolis, Ind.

Prof.M.=Professional Memoirs, Corps of Engineers and Engineer Dept. at Large, U. S. A. Washington.

R.Art.=Revue d'Artillerie, Paris.

Rev.G.=Revue du Génie Militaire, Paris.

R.Eng.J.=Royal Engineers Journal, Chatham, England.

R.U.S.I.J.=Royal United Service Institution, London. Journal.

Sci.Am.=Scientific American, N. Y.

Sci.Am.S.=Scientific American Supplement, N. Y.

Soc.Eng.=Society of Engineers, London. Transactions.

Tech.M.=La Technique Moderne, Paris.

U.S.Nav.I.=U. S. Naval Institute, Annapolis, Md. Proceedings.

W.S.E.J.=Western Society of Engineers, Chicago, Ill. Journal.

Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 51, March-April, 1918.

AERIAL ARMAMENT.

German technique in aerial armament. Jean-Abel Lefranc. (Aviation), Feb. 15, 1918. 3500 words. 15 diagrs.—Navigation lights for airplanes. (Sci. Am.), Feb. 23, 1918. 104 words.—The technical history of the airplane. Capt. F. M. Green. (Sci. Am. S.), March 2, 1918. 5350 words.

AERIAL PHOTOGRAPHY.

The camera at the front. (Sci. Am.), Nov. 24, 1917. 1400 words. Illus. See also International Military Digest, N. Y., Jan., 1918. p. 32.

AERIAL WARFARE.

Our enemies in the air. How Germany is preparing to meet American and Allied air fleets. C. Dienstbach. (Sci. Am.), Feb. 9, 1918. 2280 words. 4 half-tones.—Coöperation between balloons and artillery. Maj. D. R. Hanney. (J. R. Art.), Nov., 1917. 2915 words. 1 fold. Plate, 1 diagr.

AERONAUTICS, MILITARY.

Aircraft problems. W. F. Durand. American Soc. Mech. Engrs. Journal. Jan., 1918. p. 32-35.—America's air service. W. F. Durand. Franklin Inst. Journal, Jan., 1918. p. 1-27. 7 half-tones.—*Germany's aircraft. Independent, N. Y., Dec., 22, 1917. 138 words. See also Internat. Military Digest, Jan., 1918. p. 3.—Some Super-Zeppelin secrets. (Sci. Am.), Nov., 24, 1917. 1500 words. Illus. See also Internat. Mil. Digest, Jan., 1918. p. 11.—Italian naval aircraft. (Engi.), Jan., 4, 1918. 970 words. 6 half-tones.—What of China's air service? (Sci. Am.), Dec. 8, 1917. 275 words. See also Internat. Mil. Digest, Jan., 1918. p. 3.—Zeppelin, aeroplane and parachute. C. Dienstbach. (Sci. Am.), Dec. 22, 1917. p. 474.—*L'Aéronautique dans la grande guerre. La Nature, Paris. v. 42-2, p. 72-76. 4 half-tones. LC. (Q2 N2, v. 42-2) The same, iii. Les Dirigeables. La Nature, Paris, v. 42-2, 26 août, 1916. p. 129-136. LC. (Q2N2, v. 42-2.)

AEROPLANES.

An airplane which folds like a jack knife. (Sci. Am.), Dec. 8, 1917. 275 words. Illus. See also Internat. Mil. Digest, Jan., 1918. p. 7. *The Hansa-Brandenburg tractor. Aerial Age, N. Y., Oct. 29, 1917. 900 words. Illus. See also Internat. Mil. Digest, N. Y., Jan., 1918. p. 29.

AEROPLANE MOTORS.

Japanese aeroplane contest. (Sci. Am.), Dec. 15, 1917. p. 457. 950 words.—Liberty motor. Am. Machinist, N. Y., Dec., 27, 1917. p. 1148. 2250 words.—*Light Diesel engine possible. C. Neuman. Automotive Industries, N. Y., Dec. 27, 1917. p. 1134-1135.—Overhauling the Gnome airplane engine. Am. Machinist, N. Y., Jan. 3, 1918. p. 9-15.

AIR PROPELLERS.

Approximating the static thrust and brake horse power of air propellers. W. B. Murphy. (Aviation), Feb. 15, 1918. 1190 words. 4 diagrs.

AIR TURBINES.

Design of air turbines. A. Klemin and E. P. Warner. (Aviation), Feb. 1, 1918. p. 19-22. 7 figs.

ANCHORAGES.

Deep-water moorings in Valparaiso Bay. H. C. Anstey. Inst. C. E., v. 203, 1917. p. 371-380. 4 diagrs.

ANTI-AIRSHIP DEFENSE.

Aircraft engines at high altitudes. (Aviation), Feb. 15, 1918. 700 words. 1 half-tone.

ARMOR.

Sandbag armor on airships. (Sci. Am.), March 2, 1918. 336 words. 2 half-tones.

ASH-HANDLING. See BOILERS.

ASPHYXIATING GAS.

Gas warfare. S. J. M. Auld. (Sci. Am. S.), March 2, 1918. 5400 words.

AUTOMOBILE ENGINES.

*Duesenberg stock engine. Automotive Industries, N. Y., Dec. 27, 1917. p. 1136. Illus.

AVIATION MAPS.

Study and mapping of the atmosphere as an aid to airmen. (Sci. Am.), v. 116, May 5, 1915. p. 450.

AVIATION—Progress.

The airplane last year. (Sci. Am.), Feb. 23, 1918. 296 words.

BALLOONS. See also Aerial Warfare.

Improvement in Zeppelin design. (Sci. Am. S.), Feb. 23, 1918. 1125 words.

BLASTING.

Method and cost of clearing cut over land with powder. (Eng. C.), Dec. 19, 1917. p. 505-507.

BULKHEADS. (Piers.)

New methods in bulkhead construction. (Sci. Am.), March 2, 1918. 2300 words. 4 half-tones.

CAMOUFLAGE.

Camouflaging dynamite magazine. (Sci. Am.), Feb. 23, 1918. 80 words.

CANALS—FRANCE.

Travaux d'après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil) déc. 15, 1917.

Continuation and end of article published in issues of Dec. 1, and 8, 1917.

CANALS—TOWING.

*Le halage funiculaire électrique sur les canaux. La Nature, Paris., v. 44-2, no. 2250. Nov., 1916. p. 305-308. 5 half-tones, 1 map. LC. (Q2N2, v. 44-2.

CANTEENS.

The cost of works' canteens. (Eng.), Jan. 11, 1918. 3132 words, half-tones, 7 cross-sections.

CEMENT—CONCRETE.

Building a dam of concrete slabs. J. F. Springer. (Sci. Am.), Feb. 23, 1918. 944 words. 5 half-tones.

An interesting type of construction adopted in the Twin Cities river improvement. Illustrations: Working span that was carried away by high water.—General view of dam and lock almost completed.—Putting down a foundation of piles for

apron.—Close view of details of the dam construction showing damage done by flood.—Looking west along half-finished dam.

Special precautions necessary in winter concrete work. (Engineering and Cement World), Feb. 15, 1918. 2640 words. 1 half-tone.

Points out the necessity of exercising greater care in heating materials and in protection from freezing after placing.

CONCRETE BRIDGES.

Cost of constructing concrete arch bridge over Platte River in Nebraska. G. K. Leonard. (Eng. C.), Feb. 27, 1918. 1920 words.

CONCRETE—SEEWATER.

More comment on the behavior of sea water concrete. R. J. Wing and L. R. Ferguson. (Eng. N.), Feb. 7, 1918. 4780 words.

CONCRETE SHIPS.

Concrete ships. L. R. Ferguson. Eng. Club of Phila. Journal, Feb., 1918. p. 90-93. 5 half-tones.

CONVEYING MAHINERY.

Self-contained portable scoop conveyors. Power, N. Y., Feb. 12, 1918. p 226. 410 words. 2 half-tones.

DAMS.

Will cost half million to make Austin dam usable. D. W. Mead.(Eng.N.), Feb. 21, 1918. 990 words. 1 diagr.—Earth dam has screened gravel core and pipe drains. L. V. Branch. (Eng. N.), Feb. 21, 1918. 1560 words. 2 half-tones, 1 diagr. 1 section.—Per l'utilizzazione delle acque in alta montagna. Dighe per laghi artificiali. L. Luiggi. Annali d'ingegneria e d'architettura, Roma. July 1, Dec. 16, 1917; Jan. 1, 1918. To be continued. 7684 words. 13 half-tones. 24 diagrs.

DIVING.

*Le nouveau scaphandre entièrement métallique. J. Vichniak. La Nature, Paris. 2 sept., 1916. p. 158-160. 2 half-tones. LC. (Q2N2, v. 44-2.)

DREDGES AND DREDGING.

Recent progress in dredging machinery. Wm. Brown. Inst. C. E., v. 203, 1917. p. 212-283.

ELECTRIC TRACTORS.

Electric tractors important factor in speeding-up production. (Elect. Review, Chicago), Feb. 16, 1918. 531 words. 1 half-tone.

ELECTRIC WAVES.

Electric waves. W. S. Franklin and B. McNutt. Western Society of Eng., Chic. Journal. Nov., 1917. p. 589-622, incl. illus. diagrs.

ENGINEER TROOPS.

The work and experiences of the U. S. Engineer troops in France. Maj. Gen. Chas. M. Clement. Eng. Club of Phila. Journal, Feb., 1918. p. 57-64 and 68.

EUROPEAN WAR, 1914—See also SOMME, BATTLE ON THE.

At the front in Flanders. Lt. Gen. von Ardenne. (Infantry Journal), Feb., 1918. 2100 words.—*Impressions of a visit to the German front in

Belgium. Brig. Gen. L. de Santiago. La Guerra y su Preparación. Sept., 1917. 7000 words. See also Internat. Military Digest, N. Y., Jan., 1918. p. 15.—Sketches from the front. Maj. E. H. Lovell. (J. A. Art.), Nov., 1917. 41 words. 2 half-tones.

FIELD KITCHENS.

*Les boulangeries et les cuisines de campagne. L. Fournier. La Nature, Paris, 23 sept., 1916. p. 199-204. LC. (Q2N2, v. 44-2.)

FLOODS AND FLOOD CONTROL.

The effect of flood embankments on the river-levels in the Irrawaddy Delta. B. M. Samuelson. (Abridged). Inst. C. E., v. 203, 1917. p. 362-370. 1 map.

FLOODS AND FLOOD PROTECTION.

Plans for controlling flood waters in the Miami Valley, Ohio. (Engineering and Cement World, Chic.) Feb. 15, 1918. 1370 words. 2 sections, 2 maps.

Outlines of earthen dams and concrete work—Equipment and methods of construction.—Project to cost nearly $24,000,000.

FRENCH MORTARS. See ORDNANCE.

GAS ENGINES.

Troubles and their remedies in gas-engine ignition system. A. L. Breman, jr., Power, N. Y., Feb. 19, 1918. 1917 words.

GUNNERY.

A practical method of training gunner recruits. Maj. J. I. D'Arcy. (J. R. Art.), Nov., 1917. 638 words. 16 half-tones.

HANGARS.

Standards of construction, fire hazard and fire protection for hangars. (Aviation), Feb. 15, 1918. 1230 words. 1 diagr.

HARBORS—FRANCE—Algeria.

Les ports français et la guerre. Les ports de l'Algérie occidentale. Oran, Mostaganem, Alger et ports secondaries. A. Pawlowski. (Le Génie Civil), 26 janvier, 1918. 6170 words. 7 half-tones. 5 maps.

HARBORS—FRANCE.

Travaux d'après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil), 15 déc., 1917.

Continuation and end of articles appearing in 1 and 8, Dec., 1917. This has 2910 words.

HARBORS—Great Britain.

Ports of the empire. (Engi.), Jan. 18, 1918. 1800 words.

HAULAGE. See CANALS—TOWING.

HEAT ENGINES.

The future development of heat engines. Sci. Am. S.), Feb. 23, 1918. 531 words.

HELMETS.

*L'Évolution du casque. La Nature, Paris, v. 44-2, 15 juillet, 1916. p. 47-48. 7 half-tones. LC. (Q2N2, v. 44-2)—Punching test to indicate strength of steel trench helmets. H. A. Thomas. (Eng. N.), Feb. 21, 1918. 350 words. 1 diagr.

HIGHWAY BRIDGES.

Methods of maintaining and repairing old highway bridges. (Eng. C.), Feb. 27, 1918. 2216 words. 8 half-tones.

HOWITZERS, FIELD. See ORDNANCE.

IGNITION SYSTEMS. See GAS ENGINES.

INLAND NAVIGATION. See also CANALS—FRANCE—RIVER ENGINEERING.

*Le Rhône navigable et le tunnel du Rove. E. Coustet. La Nature, Paris, 19 août, 1916. p. 113-119. 7 half-tones. LC. (Q2N2, v. 44-2.)

INTRENCHMENTS. See also TRENCH WARFARE.

Some notes on the Turkish trenches at Samagait. Bt. Maj. W. H. Lang. United Service Institution of India. Journal. Oct., 1917. 3000 words. 1 map. See also Internat. Military Digest, N. Y., Jan., 1918. p. 14.—Description of a battle trench pumping outfit. Lieut. W. A. Edwards. (U. S. Nav. I.), Dec., 1917. p. 2921-2925, incl. illus.

KITE BALLOONS.

Fighting U-boats from towed kite balloons. (Sci. Am.), Feb. 9, 1918. 210 words. 1 half-tone, and frontipiece.

LABOR.

Training of workmen for positions of higher responsibility. F. C. Stanford. Am. Institute of Mining Engrs. Bulletin. Feb., 1918. 5808 words.—Social and religious organizations as factors in the labor problem. E. E. Bach. Am. Inst. of Mining Engrs. Bulletin. Feb., 1918. 2580 words.

LOCOMOTIVES.

Some British locomotives of 1917. (Engi.), Jan. 11, 1918. 2890 words. 5 half-tones. 2 diagrs.

MACHINE GUNS.

The tactics of the machine gun. U. S. Cavalry Association. Journal. Jan., 1918. 13850 words.

MARINE RAILWAY.

Cable inclines carry boats over Illinois River levee. (Eng. N.), Feb. 21, 1918. 1350 words. 2 half-tones. 2 diagrs.

MASONRY DAMS—Design.

A new method of designing masonry dams. A. A. Stoddard. Inst. C. E., v. 203. p. 401-412.

MICROSCOPE.

The use of the miscroscope in engineering. (Engi.), Jan. 18, 1918. 750 words.

MICROPHONE.

Aerial range-finding with electrical ''ears.'' (Sci. Am.) no. 18, Oct. 30, 1915. p. 377. front. illus.

A microphone system of detecting invisible airships and determining ranges.

MILITARY BRIDGES.

Building a pile bridge to victory. (Sci. Am.), March 2, 1918. 200 words. Illustration: Temporary bridge building carried out by French engineers.

MILITARY MINES.

*La guerre de mines. Par ''Un vieux mineur.'' La Nature, Paris. 7, Oct., 1916. p. 225-230. 4 half-tones, 3 diagrs., 1 cross-section. LC. (Q2N2, 1. 44-2.)

MILITARY MINING.

Blowing up the enemy. Large-scale mining operations as a weapon of offensive warfare. (Sci. Am.), Feb. 23, 1918. 1096 words. 3 half-tones.

Illustrations—Frontispiece: Firing a mine under the enemy's position. 1. French sappers on the western front making good use of a pneumatic drill.—What happens when a mine exploded: work of Canadian sappers in France.—Using a pneumatic drill in French mining operations on the Western Front.

MILITARY RAILROADS.

*Les chemins de fer dans la conduite et la poursuite de la guerre. La Nature, Paris, 2 sept., 1916. p. 145-150. 6 half-tones. LC. (Q2N2, v. 44-2.)

MILITARY ROADS.

Military road building. Sgt. B. C. White. Power, N. Y., Feb. 19, 1918. 396 words. 9 half-tones.

MILITARY TOPOGRAPHY.

Engineers assist in military mapping. (Eng. N.), Feb. 14, 1918. 720 words.

MILITARY TRAINING.

Infantry training under adverse conditions. Lt. Col. C. B. Stone. |Inantry Journal), Feb., 1918. 590 words.—A plan for practical training of reserve officers. Maj. Chas. Burnett. U. S. Cavalry Association. Journal. Jan., 1918. 950 words.

MODELS.

The world in miniature. Why models are built and how they are built. (Sci. Am.), Feb. 23, 1918. 1944 words. 5 half-tones.

MOTOR CARS AND TRUCKS. See also ELECTRIC TRACTORS.

Motor trucks relieve railways. Editoral. (Am. Machinist), Feb. 28, 1918. 468 words.—Plan proposed to relieve freight congestion in New York. (Electrical Review Chicago), Feb. 1, 1918. 729 words.—Semi-trailers put haulage on war-time basis. (Engineering and Cement World), Feb. 15, 1918. 650 words. 1 portr. *Q. M. C. Class A truck is internal gear driven. Commercial Vehicle, N. Y., Dec., 1917. 1200 words. See also International Military Digest, N. Y., Jan., 1918. p. 32.

NAVIGATION LIGHTS. See AEROPLANES.

NITRATE INDUSTRY.

The Chilean nitrate industry. A. H. Rogers. Am. Inst. of Mining Engrs. Bulletin. Feb., 1918. 8195 words. 3 half-tones.

OCEAN TERMINALS.

American railway yard and terminal development in France presents many new problems. R. Tomlin, jr. (Eng. N.), Feb. 21, 1918. 2480 words.

OIL AND GAS ENGINES. See GAS ENGINES.

ORDNANCE. See also SMALL ARMS.

The erosion of guns. H. M. Howe. Am. Inst. of Mining Engrs. Bulletin. Feb., 1918. 26160 words. 17 half-tones. 10 diagrs.—Shells that will dive. (Sci. Am.), Feb. 9, 1918. 600 words. 3 half-tones.—High-angle fire artillery the back-bone of the Austrian army. (Sci. Am.), Feb. 23, 1918. 344 words. 3 half-tones.

PACKING GOODS.

Packing for export. J. F. Hart. (Am. Machinist), Feb. 28, 1918. 324 words.

PASSENGER STATIONS—STAIRWAYS.

Safety provisions for construction of stairways for passenger stations. (Eng. C.), Feb. 27, 1918. 1560 words.

PHOTOGRAPHY.

The special selectivity of photographic deposits. i. Theory, nomenclature, and methods. L. A. Jones and R. B. Wilsey. Franklin Institute, Phila. Journal. Feb., 1918. p. 231-267, incl. diagrs.—Weakening [or reducing] of photographic prints. (Sci. Am. S.), Feb. 23, 1918. 333 words.

PIERS.

Double-deck concrete wharf-house pier at Galveston. (Engineering and Cement World), Feb. 15, 1918. 880 words. 2 half-tones.

First reinforced concrete warehouse in the South.—Increases cotton handling capacity of Galveston by quarter million bales annually.

RAILROAD BRIDGES.

On the physical features of ''Adam's Bridge'' and the currents across it, considered as affecting the proposed construction of a railway connecting India with Ceylon. Inst. C. E., v. 203, 1917. p. 284-332. 2 sections.

RAILROADS, ELECTRIC.

Railroad electrification a solution of acute transportation problem. E. W. Rice, jr. (Electrical Review, Chicago), Feb. 23, 1918. 3285 words also in: Power, Feb. 26, 1916. p. 310-311.

Important address at opening of Midwinter Convention of A. I. E. E.—Big fuel saving and increase of track capacity most timely advantages of electrical operation.

RAILROAD STATIONS—See PASSENGER STATIONS.

RAILS.

The creep of rails. F. Reeves. (Eng.), Jan. 18, 1918. 1710 words.—Creeping and roaring rails. (Engi.), Jan. 18, 1918. 2390 words.—Wheel contacts on railheads. G. H. Barbour. (Eng. S. W. P.), Nov., 1917. 10480 words. 18 diagrs.

REFUGE DISPOSAL.

Refuge disposal. R. Hering. Western Soc. Eng., Chicago. Journal. Nov., 1917. p. 623-644, incl. diagrs.

RESPIRATORS.

L'Exposition des appareils respiratoires au Musée du Valde-Grâce. La Nature, Paris. 7 oct., 1916. p. 230-234. 5 half-tones. LC. (Q2N2, v. 44-2.)

RHONE RIVER. See RIVER ENGINEERING.

RIFLES. See SMALL ARMS.

RIVER ENGINEERING.

*Le Rhône navigable et le tunnel du Rove. E. Coustet. La Nature, Paris. 19 août, 1916. p. 113-119. 7 half-tones. (LC. Q2N2, v. 44-2.)—Travaux d'après-guerre dans les ports, les rivières et les canaux. P. Mallet. (Le Génie Civil), 15. déc., 1917. 2910 words.

This is the continuation and end of articles in numbers 1. and 8. Dec., 1917. of the same periodical.

SALVAGE.

Successful handling of a difficult salvage task. (Sci. Am.), Feb. 9, 1918. 1730 words. 3 half-tones.

SEARCHLIGHTS.

*Le projecteur Sperry. La Nature, Paris. 25 nov., 1916. p. 352. 1 half-tone. LC. (Q2N2, v. 44-2.)

Characteristics and testing of war searchlamps. Lieut. Sam. G. Hibben. (Electrical World), Sept. 1, 1917, p. 419-421. 1881 words. 4 half-tones, 4 charts.—Editorial: The searchlight in practice, p. 386.

Sizes of electrodes for different projectors. Relation of focal length to diameter of mirror, difficulties in measuring beam candlepower and other points of interest.

SHELL-PROOF QUARTERS.

Concrete shelters which weather the enemy's artillery storm. (Sci. Am.) Feb. 23, 1918. 160 words. 1 half-tone.

SHERBURNE LAKES DAM. See DAMS.

SHIPPING. See also PACKING GOODS.

SMALL ARMS.

Uncle Sam's new infantry rifle. E. C. Crossman. (Sci. Am.) Dec. 1, 1917. 2100 words. Illus. See also International Military Digest, N. Y., Jan. 1918, p. 12.

Treats on the Enfield rifle. Periscopic or altiscopic rifles. (Sci. Am. S.) Feb. 23, 1918. 567 words. 3 diagrs.—Musket manufacture in past centuries. H. H. Manchester. (Am. Machinist), Feb. 28, 1918. 1188 words. 6 half-tones.

SOMME, BATTLE OF THE, 1916.

The battle of the Somme. Capt. A. V. Gompertz. United Service Institution of India. Journal. Oct., 1917. 12000 words. 1 map. See also Internat. Mil. Digest, N. Y. Jan., 1918, p. 33.

STAIRWAYS. See PASSENGER STATIONS—STAIRWAYS.

STEEL—TESTING.

Results of steel column tests of Special Committee. A. Soc. Civil Engineers. (Eng. C.) Feb. 27, 1918. 2560 words.

STORAGE.

Modern methods for the storage of coal. ii. G. F. Zimmer. (Eng.), Jan. 18, 1918. 2160 words, 1 half-tone, 13 cross-sections.

SUBMARINES. See also KITE BALLOONS.

The new German submersible. (Engi.), Jan. 18, 1918. 540 words.

SUBMARINES, DEFENSE AGAINST.

La défense du commerce maritime contre les sous-marins. (Le Génie Civil), 16. déc., 1917. 4620 words. 1 map.—Offensive against the submarine. Jos. A. Steinmetz. (Eng. C. P.) Feb. 1918, p. 69-80, incl. 1 portr., 10 half-tones, 2 sections. Filming the sea with oil to beat the U-boat. Letter to the editor. D. F. Zook. (Sci. Am.), FFeb. 23, 1918. 800 words.

SUBMARINE SAWS.

Submarine saw removes weeds in streams and lakes. (Eng. N.), Feb. 14, 1918. 600 words.

SURVEYING.

A new device for tachoemetric plane-table surveying. H. Louis. Inst. C. E., v. 203, 1917, p. 359-361.

Treats on the "Patent compensating subtense diaphragm," made by W. F. Stanley & Co., London, with brief mention of the instruments by Ljungström and Prof. Jeffcott, the latter made by Thomas Cooke & Sons, lim., London.

TELEPHOTOGRAPHY.

Telescopic-telefotoapparato. Rivista di Artiglieria e Genio, Roma. Oct.-Nov. 1, 1917. 620 words.

TESTING STEEL. See STEEL—TESTING.

TOWING—CANALS. See CANALS—TOWING.

TRACTION ENGINES, (MILITARY). See also ELECTRIC TRACTORS.

Layritz, O. Mechanical traction in war. For road transport. Lond., 1900.

TRACTORS.

Some British agricultural tractors and haulers. IV. (Engi.), Jan. 4, 1918. 2300 words. 4 half-tones, 4 diagrs.; V. Martins' Cultivator Co. (Engi.), Jan. 18, 1918, 3250 words, 4 half-tones.

TRACTORS, (MILITARY).

An early form of the famous caterpillar tractor. W. D. Forbes. (American Machinist), Feb. 14, 1918. 250 words.

TRANSPORTATION. See also RAILDOADS, Electric.

TRENCHES, SANITATION OF.

Description of a battle trench pumping outfit. Lieut. W. A. Edwards, U. S. N. (U. S. Nav. I.) Dec., 1917, p. 2921-2925, incl. illus.

TRENCH WARFARE.

Trench warfare. J. M. M. (Menorial de Ingenieros), Aug. 1917. 5280 words. See also Internat. Military Digest, N. Y., Jan., 1918, p. 27.

Trench gates and trench raids. (Sci. Am.) Feb. 23, 1918. 176 words.

TRIPLEX GLASS. See AVIATION—TRIPLEX GLASS.

WATER-SUPPLY.

Per l'utilizzazione delle acque in alta montagna. Dighe per laghi artificiali. L. Luiggi. Annali d'ingegneria e d'architettura, Roma. July 1, Dec. 1, 1917; Jan. 1, 1918. To be continued. 7684 words. 13 half-tones, 24 diagrs.

WHARVES. See also PIERS.

WORKMEN. See LABOR.

ZEPPELINS. See BALLOONS.

Articles of Engineering Interest.

Compiled with a view to including articles of civil and military engineering subjects of special interest to the readers of PROFESSIONAL MEMOIRS, Corps of Engineers and Engineer Department at Large. By Henry E. Haferkorn, Librarian, Engineer School.

The following abbreviations are used, viz:

Am.Soc.C.E.P.=American Society of Civil Engineers, N.Y. Proceedings.

Am.Soc.C.E.T.=American Society of Civil Engineers, N. Y. Transactions.

A.P.C.=Annales des Ponts et Chaussées, Paris.

A. R.=The Army Review, London.

Assoc'n E.S.=Association of Engineering Societies, St. Louis, Mo. Journal.

B.Eng.C.=Brooklyn Engineers' Club, Brooklyn, N. Y. Proceedings.

Ca.E.=Canadian Engineer, Toronto, Can.

Ca.S.E.=Canadian Society of Civil Engineers (Montreal), Transactions.

Cem. E.=Cement Era, Chicago.

Conn.S.C.E.=Connecticut Society of Civil Engineers, New Haven, Conn. Papers and Transactions.

Con.=The Contractor, Chicago.

De Ing.=De Ingenieur Hague, Holland.

Engi.=The Engineer, London.

Eng.=Engineering, London.

Eng.C=Engineering and Contracting, Chicago.

Eng. M.=Engineering Magazine, N.Y.

Eng. N.=Engineering News, N.Y.

Eng. R.=Engineering Record, N. Y.

Eng.C.P.=Engineers' Club of Phila. Proceedings.

Eng.S.P.=Engineers' Society of Pennsylvania. Harrisburg. Journal.

Eng.S.W.P.=Engineers' Society of Western Penn'a. Pittsburg, Pa. Proceedings.

Inst.C.E.=Institution of Civil Engineers, London. Minutes of Proceedings.

Inst.Eng.Sh.=Institute of Engineers and Shipbuilders in Scotland, Glasgow. Transactions.

Int.R.=Internationale Revue über die gesamten Armeen und Flotten, Dresden.

J.R.Art.=Journal of the Royal Artillery, Woolwich, England.

J.U.S.Art.=Journal, U. S. Artillery, Fort Monroe, Va.

K.T.=Kriegstechnische Zeitschrift, Berlin.

Mu.E.=Municipal Engineering, Indianapolis, Ind.

Prof.M.=Professional Memoirs, Corps of Engineers and Engineer Dept. at Large, U. S. A. Washington.

R.Art.=Revue d'Artillerie, Paris.

Rev.G.=Revue du Génie Militaire, Paris.

R.Eng.J.=Royal Engineers Journal, Chatham, England.

R.U.S.I.J.=Royal United Service Institution, London. Journal.

Sci.Am.=Scientific American, N. Y.

Sci.Am.S.=Scientific American Supplement, N. Y.

Soc.Eng.=Society of Engineers, London. Transactions.

Tech. M.=La Technique Moderne, Paris.

U.S.Nav.I.=U. S. Naval Institute, Annapolis, Md. Proceedings.

W.S.E.J.=Western Society of Engineers, Chicago, Ill. Journal.

Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 52, July-August, 1918.

AERIAL PHOTOGRAPHY.

French cameras which snap the enemy's works against his will. (Sci. Am.), March 9, 1918. 300 words, 1 illus.

AERIAL WARFARE, See also ANTI-AIRCRAFT GUNS—BALLOON GUNS.

L'armamento e l'impiego offensivo delle aeronavi. Enrico Maltese, capitano d'artiglieria. Rivista di Artiglieria e Genio, Roma. Gennaio, 1914, p. 61-83; febbraio, 1914, p. 137-172.

AEROPLANES—CONSTRUCTION.

Mass of material to construct an airplane. (Sci. Am.), March 9, 1918. 160 words.

ANTI-AIRCRAFT GUNS. See also AERIAL WARFARE.

Il tiro di artiglieria contro gli aerei. Sallustio Regii, maggiore d'artiglieria. (Rivista di artiglieria), Ottobre-nov., p. 45-77; dicembre, 1917, p. 178-211, incl. diagrs., 1 fold. plate.—Contents.—Preliminaries.—Il tiro preparato antiaereo. 1. Il problema balistica del tiro. 2. Il movimento del bersaglio.—Ipotesi ammesse circa il volo.—3. Sistemi a tiro continuo ed.

BARRAGE FIRE.

Barrage fire of machine gun. (Infantry Journal,). April 1918, 2576 words.

BIBLIOGRAPHY.

Aerial photography. Part 1. Photo-topography, etc. (Prof. M.), May-June, 1918, p. 421-436. To be continued in subsequent numbers. Poisonous gas in warfare. (Prof. M.), Nov.-Dec., 1917, p. 758-784; Jan.-Feb., 1918, p. 143-156.

BOMB-PROOF SHELTERS.

Deep gallery shelters. A lecture by Col. P. S. Bond and Lieut. R. D. Leisk, 107th Engineers, N. A. (Prof. M.), Jan.-Feb., 1918. 3528 words, 3 cross-sections.—Use of corrugated iron for construction of shelters. Trans. from reliable sources by Maj. Henry Swift, Chaplain, U. S. A. (Prof. M.), Jan.-Feb., 1918. 3660 words, 6 plans, 2 cross-sections.

BROWNING GUN. See MACHINE GUNS.

CAISSONS.

Method of constructing and sinking floating caissons for a bridge pier. (Eng. C.), April 17, 1918. 2256 words.

CAMOUFLAGE.

American corps for camouflage. S. E. Fry, (Am. Arch.), July 25, 1917, p. 68.—Art of camouflage. (Am. Arch.), Nov. 14, 1917. p. 360.—Marine camouflage and its relation to the U-boat campaign. (Sci. Am.), Sept. 1, 1917. p. 158, illus.—Notes on camouflage. J. A. Smith. (Architectural Record.), Nov. 1917. p. 468-477.

Nouvelle methode de camouflage. (Thayer). LeGenie Civil, 20 avril, 1918, p. 288.210 words.—Seeing but not seen. (Sci. Am.), May 18, 1918, p. 451. 956 words, 6 half-tones.—What our camoufleurs are learning day by day in their newly-found art.

(Recent artifices of modern war.) Reprint from Risorgimento. Revista Militar, Buenos Aires, Arg. Rep., Sept., 1917. 1200 words. Reviewed in

International Military Digest, Feb., 1918, p. 64.—Subject of camouflage. (Journal of the American Institute of Architects), Aug., 1917, p. 382.

CAMP SANITATION.

Camp Merritt as a construction problem. (Mu. E.), Dec. 15, 1917, p. 577.—Conserving the health of our troops in the cantonments. P. R. Davison. (Domestic Engineering, Chicago), Dec. 15, 1917, p. 432-433.—Construction features of water supply system and sewerage works for the Camp Custer Cantonment. (Eng. C.), Dec. 12, 1917, p. 479-482. Illus.—Design and construction of water and sewer system at Camp Custer, Battle Creek, Mich. D. W. Bingham. (Mu. E.), Dec., 1917, p. 214.—Solving the water supply and sewerage problems at the Camp Pike Cantonment. E. B. Black. (Mu. E.), Nov., 1917, p. 177. Illus.

CHALEROI, BATTLE OF, Aug., 1914.

The battle of Chaleroi. Maj. T. E. Crompton. (R. U. S. I. J.), Feb., 1918. 7500 words. 2 sketch-maps.—See also the digest of this article in International Military Digest, April, 1918, p. 168-170.

CONCRETE ROADS.

Adopt belting and rolling methods for concrete roads. H. E. Bilger. (Eng. N.), March 7, 1918. 1050 words.—Motor trucks and concrete roads and solving transportation problems. (Engineering and Cement World), March 1, 1918. 1750words.

CRANES, HOISTS, etc., See also HARBORS—EQUIPMENT.

Eries' new cranes. E. L. Hill. (Freight Handling and Terminal Engineering), Feb., 1918. 1460 words. 3 half-tones.

ENGINEER TROOPS—INLAND WATERWAYS REGIMENT.

Inland waterways regiment being recruted. (Eng. N.), April 11, 1918, p. 734-735.—Men familiar with canal operations wanted for service in France as engineer troops.

ENGINEER TROOPS—ITALY.

Il genio militare italiano nelle guerre de 1848 e 1849. Mariano Borgatti, Colonnello del genio in p. a. Rivista di Artiglieria, Roma. Gennaio, 1914, p. 27-53. Ports. and maps; febbraio, 1914, p. 173-216.

ENGINEER TROOPS—UNITED STATES.

How to join the Army Engineers. (Am. Soc. Mech. Eng.) Journal. April, 1918. 600 words.

EUROPEAN WAR, 1914.—See also ENGINEERING.

Impressions from the Austro-Hungarian front. vii. Trans. by Capt. G. de L. Landon. (J. R. Art.), Dec. 1917. 4950 words.—The Italo-Austrian theatre of operations. (Roy. Eng. J.), Feb., 1918. 1392 words. Abstracted from "Revue Militaire Suisse," Sept., 1917.

FLAME PROJECTORS.

Instructions for the employment of flame projectors. Infantry Journal. March, 1918. 3864 words. Translation from a German document dated Dec. 12, 1915.

FORTIFICATIONS, FIELD.

Giulio Cesare e la querra di posizione nella campagna ispanomarsigliese dell' anno 49 a. C. Per G. Suchet, Tenente generale. (Rivista di Artiglieria e Genio, Roma. v, 3), Sept., 1917, p. 193-215. 2 maps (part fold). To be continued. (No continuation in v 4), v. 2 Aprile-Maggio, 1917, p. 21-49. 3 fold. maps.

FREIGHT HANDLING.

How freight-handling machinery is being used abroad. H. Varndell. (Eng. N.), April 11, p. 711-715. 4 half-tones.—For trans-shipment at ports and for warehouse movements the lack of labor in the war zones leads to the application of mechanical aids.

HARBORS.

Ports and terminal facilities. R. S. MacElwee. (Eng. C. P.), April, 1918, p. 165-175; 208. 8 half-tones, 2 plans.—With discussion by Mr. Geo. S. Webster, Director of Dept. of Wharves, Docks and Ferries, Philadelphia. Treats on domestic and foreign freight piers and freight transfer systems.

MACHINE GUNS.

Barrage fire of Machine Gun. (Infantry Journal.), April, 1918. 2576 words.—Tactics of the Machine Gun. R. V. K. Applin (Infantry Journal), April, 1918. 5152 words.—The Browning machine rifle and gun. (Am. Machinist), March 21, 1918. 1150 words, 3 half-tones.—Preliminary facts concerning the Browning guns. (Sci. Am.), March 9, 1918. 1250 words. 4 half-tones.

MEXICO.

The frontier region of Mexico. Notes to accompany a map of the frontier. Geog. Review, N. Y. v. 3, 1917, p. 16-27. 1 text-map, 4 half-tones, 1 col. map (fold.).—The half-tones show activities of U. S. Army during the recent Punitive Expedition.

MILITARY BRIDGES. See also MILITARY ENGINEERING.

Bridge training of a battalion of mounted engineers. By the Regimental commander. (Prof. M.), March-April, 1918. 2770 words. 4 half-tones.

MILITARY ENGINEERING.

Instruction of engineer troops while in quarantine. By the Regimental and Company commanders. (Prof. M.), March-April, 1918. 1420 words. 12 half-tones.—Illustrations.—Figs. 1-3. Gallery entrance, etc. Figs. 4-5. Suspension bridge. Fig. 6. Double bow-string truss bridge. Fig. 7. Lattice truss bridge. Figs. 8-9. Arch culvert. Fig. 10. Trenches in miniature Fig. 11. Gabions, fascine and brush revetment. Fig. 12. Pile driver.

MILITARY MINING See also MILITARY TUNNELING.

Mining operations especially for infantry. Mainly trans. from a lecture to cadets at Saint-Mairent, France, by Col. W. R. Livermore. (Prof. M.), Jan.-Feb., 1918. 5550 words. 7 diagrs., 12 cross-sections.

MILITARY RAILROADS.

Large mileage of light railways will serve American troops at the front. R. T. Tomlin, Jr. (Eng. N.), March 14, 1918. 2500 words, 3 half-tones.

Dept. organized for big construction program.—Relation of light railways and highways explained.—Narrow gauge lines have been big factors in relieving congestion of motor trucks on roads.

MILITARY RAILROADS—NARROW GAUGE.

Le material des voies étroites stratégiques allemandes et autrichiennes. G. Mangin. (Le Génie Civil). April, 1918, p. 229-233. 4 half-tones, 17 cross-sections.

MILITARY TELEPHONES.

Telefonia militare da campo. Giuseppe Guasco, capitano del genio. Rivista di Artiglieria, Roma. Giugno, 1914, p. 316-361. 2 fold. plates.

MILITARY TRANSPORTATION.

Battle front transportation. Lieut. R. Haydock, Engr. R. C. (Prof. M.), May-June, 1918. 6900 words, 23 half-tones, 3 diagrs.—Rail and motor transport as applied to military operations. Col. P. S. Bond, Corps of Engineers, N. A. (Prof. M.), Jan.-Feb., 1918. 7500 words.

MILITARY TUNNELING. See also MILITARY ENGINEERING.

Tunnels and galleries. From ''La France Militaire,'' Paris. Trans. by Col. W. R. Livermore. (Prof. M.), May-June, 1918. 925 words.

MILITARY VEHICLES—WEIGHTS.

Weights and measures. By O. C. of a field company, R. E. (Roy. E. J.), Feb., 1918. 300 words.

MOTOR CARS AND TRUCKS.

Long-distance motor trucking. C. E. Stone. (Mu. E.), March, 1918.—The motor truck and the transportation problem. (Sci. Am.), March 9, 1918. 200 words.—Traction on bad roads or land. L. A. Legros. (Eng.), Jan. 25, 1918. 3350 words. 10 half-tones, 1 plan, 5 diagrs.—Unbroken bulk big feature transporting freight by motor trucks. Letter to editor. D. O. Skinner. (Mu. E.), March, 1918. 380 words.

OBSERVATION TOWERS.

Scale-osservatorio in uso nell' artiglieria da campagna Austro-Ungarica, Francese e Tedesca. Rivista di Artiglieria, Roma. Marzo, 1914, p. 347-351. 2 fold. plates.—Treats on observation ladders and towers for field artillery.

OCEAN TERMINALS.

Port terminals for war transportation being built. (Eng. N.), March 7, 1918. 2150 words, cross-sections, elevations, diagrs., etc. Contain large standardized timber warehouse units and open storage spaces—Filled from cars or trucks and emptied by tractor-trailer to ships.

ORDNANCE.

British and German naval ordnance. 1. British ordnance. (Engi.), Feb. 8, 1918. 3760 words. 2. Naval gun supply, Feb. 8, 1918.

ORDNANCE—NAVAL.

British and German naval ordnance. 3. Modern German guns. (Engi.), Feb. 15, 1918. 1410 words.

PHOTOGRAPHY.

The sensitometry of photographic intensification. A. H. Nietz and K. Huse. (Franklin Inst.), Journal, March, 1918, including bibliography. 6690 words, 6 diagrs.

PREPAREDNESS.

The preparedness of the future. Cmdr. H. O. Rittenhouse, U. S. N., ret. (U. S. Nav. I.), April, 1918, p. 733-765.

REGIMENTAL RECORDS.

The collection of material for a regimental record of the war. Lieut. Col. A. F. Mockler-Ferryman. (R. U. S. I. J.), Feb., 1918. 5080 words.

SAPPING. See also INTRENCHMENTS.

Sapping operations, especially for infantry. From a lecture at Saint Maixant, France. Capt. A. Gay, French Army. Trans. by Col. W. R. Livermore. (Prof. M.), March-April, 1918. 3870 words, 23 figs.

STREAM CROSSINGS.

Short account of crossing the Tigris by a division. Brig. Gen. H. J. A. Mackey. (J. R. Art.), Dec., 1917. 1847 words, 1 map.

''TANKS.'' See TRACTORS, MILITARY. See also TRACTION ENGINES.

TRACTORS, MILITARY.

Armored automobiles. A war machine that has undergone many changes. (Scientific American Supplement, N. Y., v. 83, no. 2140, Jan. 6, 1917, p. 4-5. Also in: Army War College Library. Monthly list, Feb., 1917, no. 38.) See illustration (half-tone), p. 4: One of the ''Insolent'' British tanks, employed at the Somme front.—Armored cars, European war. A German description of the British ''Tanks.'' From Japan Advertiser, Dec. 25, 1916. Army War College Library. Monthly list. March, 1917, no. 43.—Armored cars, European war. Picture of a British ''Tank'' car in action. From N. Y. Times, Dec. 17, 1916. Army War College Library. Monthly list. Feb., 1917. no. 37.—Armored cars and British tanks in the war. From La Swiss Sportive, Geneva, Oct. 14, 1916. Army War College Library. Monthly list, Jan., 1917. no. 38. —Armored caterpillar tractor. Army and Navy Journal, N. Y., Sept. 23, 1916. 750 words. See also International Military Digest, N. Y. Annual, 1916, p. 74.—Armored tractors in the European war. (Scientific American, N. Y. v. 115, Oct. 7, 1916, p. 322-323. 2000 words. Illus.) Army War College. Monthly list, Nov. 1916. no. 39. See also International Military Digest, N. Y. Annual, 1916, p. 74.—The automatic land cruiser. Part played by American company in developing the ''Tanks'' of French battlefields. (Iron Age, N. Y., Sept. 28, 1916, p. 695, illus. Army War College. Monthly list, Nov., 1916. no. 38.)—Automobili corazzati e armati da battaglia i ''Tanks'' inglesi. Rivista di Artiglieria e Genio, Roma. xxxiv (54a) annata, v. 1. Gennaio, Febraio e Marzo, 1917, p. 98-103. 1940 words. 1 half-tone (2 figs.).—British armored ''Tank'' cars. (Current History, N. Y. Times, N. Y., Nov., 1916, p. 242. Illus. Army War College Library. Monthly list, Dec., 1916, no. 47.)—Britain's super-dreadnoughts of the land. (Literary Digest, N. Y., v. 53, Sept. 30, 1916, p. 815-817. Illus., map.)

TRENCH GUNS. (MINENWERFER.)

Minenwerfer. (Schweizerische Zeitschrift fuer Artillerie), April, 1918, p. 115-119.

TRENCH WARFARE. See also INTRENCHMENTS.

Organization and duties for trench fighting. Capts. O. N. Solbert, Corps of Engineers, U. S. A., and G. Bertrand, French Army. (Prof. M.), Jan.-Feb., 1918. 4000 words. May-June, 1918. 9000 words. 6 outline figs.—Trench organization. Gen. R. Radiguet, French Army. (Prof. M.), May-June, 1918. 5500 words, 8 half-tones, 4 figs., 1 plate.—Trench artillery. E. Van Bode. Infantry Journal. March, 1918. 3790 words. From Revue Militaire suisse, Aug., 1917.—A trench raid. (Roy. E. J.), Feb., 1918. 865 words. Abstracted from ''Revue Militaire Suisse,'' Sept., 1917, which obtained the article from an acount published in Infantry Journal, June, 1917.

ENGINEER TROOPS.

Duties of Engineer and Infantry officers with regard to working parties. (Infantry Jounrnal), July 1918, p. 65-67.

1. Relations between the officer i. c. of the working party and the R. E., or other officer, under whose direction the work is being done. 2 Organization of work. 3. General remarks.

EUROPEAN WAR, 1914--ARTILLERY, BELGIAN.

The Belgian field artillery in the present war. Lieut. E. Van Erde. (Field Art. Journal.) April-June, 1918, p. 182-207. 5 illus. (on 3 plates).

Author is Lieut. of the Belgian army. The above is translated by Geo. N. Tricoche, late officer. French Artillery.

EUROPEAN WAR, 1914—ENGINEER SERVICE.

How the war has increased the Corps of Engineers. (Eng. N.), July 11, 1918, p. 85; 630 words.

Officers and men before the war were 2500. There are 200,000 now, more than half of them in France.

Conditons and requirements of warfare. Major J. E. Cassidy, 301st Engineers, Camp Devens, Ayer, Mass. (Am. Soc. Mech. Eng.), Journal, July, 1918; p. 551-553.

The need of specialists in the present war. A. Morize. (Am. Soc. Mech. Eng.), Journal, July, 1918; p. 554-555.

Contents.—The need for technical training.—The war one of the specialists.—Training in use of new weapons necessary. Question of artillery transportation most important.

This paper was read by Lieut. André Moriz, French Military Mission, Northern District; detailed to Dept. of Military Science and tactics, Harvard University at Worcester meeting, June 4-7, 1918, on the subject of "Emergency technical war training."

Specialized training of technicians. A. L. Williston, (Am. Soc. Mech. Eng.), Journal, July, 1918; p. 553-554.

Contents.—The war's demand on the engineer.—Urgent need of additional shipping.—The special obligation of the society.—The need for technical training.

This is one of the papers read on "Emergency technical war training" during the spring meeting of the Am. S. M. E., at Worcester Polytechnic Institute, June 4-7, 1918, at Worcester. Mass.

EUROPEAN WAR, 1914—NAVAL OPERATIONS.

L'Embouteillage des entrees des ports d'Ostende et de Zeebrugge par les Anglais, le, 22-23 avril. A. Poidloue, Captaine de vaisseau en retraite. (Le Génie Civil), 4 mai 1918, p. 309-313. 3 half-tones, 8 plans, sections, etc.

EUROPEAN WAR, 1914—ORDNANCE. See ORDNANCE.

EUROPEAN WAR, 1914—WESTERN FRONT, July, 1918.

From the trenches to open warefare. (Sci. Am.), July 27, 1918, p. 68-69; 76. 10 half-tones.

How the Von Hutier method of attack broke the deadlock on the Western front. Illustrations show French field howitzers—Railway guns mounted in turrets and manned by French sailors—The French Fillioux gun long-range 305-mm. or 16-in heavy artillery batteries, etc.

EXPLOSIVES.

Explosif a oxygéne liquide (exiiquide) employé dans les mines en Allemange. (Le Génie Civil.), 1 juin, 1918; p. 399-402. 6 figs. 2 tables.

Treats on "sprengluft" (explosive air) used as a substitute for mining purposes in Germany on account of the shortage of ordinary explosives.

An abstract of this article in (Engi.), June 14, 1918.

FOREIGN RELATIONS—UNITED STATES. See UNITED STATES—FOREIGN RELATIONS.

FORTIFICATION, FIELD.

Emppleo del concreto en la fortificacion moderna. (Boletin de Ingenieros Mexico), Marzo, 1918; p. 43-45. 1 half-tone, plans, section.

FOUNDATION.

Repairing a drop stamp foundation (Engi.), June 21, 1918; p. 534. 1 half tone, 4 sections.

FREIGHT HANDLING. See FREIGHT AND FREIGHTAGE.

FREIGHT* AND FREIGHTAGE. See also ELECTRIC TRUCKS—AUTOMOBILES, STEAM—MOTOR CARS AND TRUCKS.

Freight handling at marine terminals. (Freight H.), June, 1918; p. 197-199.

FUEL.

The economical use of fuel. (Am. Soc. Mech. Eng.), Journal, July, 1918; p. 601-660. Half-tones diagrs., tables.

A symposium contributed to the Worcester meeting, Am. Soc. Mech. Engineers, at Worcester Polytechnic Institute, June 4-7, 1918.

The possibilites of powdered coal, as shown by its combustion characteristics. W. C. Wilcox (Sci. Am. S.), July 27, 1918; p. 62-64.

Paper read before the Western N. Y. Section of the American Chemical Society, May 31, 1918.

GAS ENGINES.

Development of the Diesel type marine heavy-oil engine in the United States. G. A. Colley. (Am. Soc. Nav. Eng.), May, 1918; p. 370-374.

Treats on American Diesel engine builders. West Coast activities. Economy and reliability. Steam and electrical auxiliaries. Operation of the engines.

The heavy oil engine. C. E. Lucke. (Eng. C. P.), June, 1918; p. 269-279.

Troubles and their remedies in gas engine ignition systems. H. B. Wilson. (Power), May 28, 1918; p. 775. 162 words.

The use of tar oil fuel in Diesel engines. (Eng.), April 26, 1918; p. 472. 900 words.

The heavy oil engine. C. F. Lucke. (Sci. Am. S.), July 27, 1918; p. 50-51, Aug. 3, 1918; p. 78-80.

A review of the present construction and future development.

From a paper read before the Engineer's Club of Phila.

Werkspoor marine Diesel engines. (Eng.), June 7, 1918; p. 634; June 14, 1918; p. 658. 15 figs., half-tones, plans, sections.

GUN EMPLACEMENTS.

Calculations necessary for the construction of dug-outs and gun pits. Temp. Maj. F. M. G. DuPlat-Taylor, R. G. A. (J. R. Art.), June, 1918; p. 107-116. 6 figs. (Sections, diagrs., tables).

HALIFAX HARBOR. See HARBORS—CANADA.

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Coal-handling plant at the Saltey gas works. G. F. Zimmer, (Engi.), May 17, 1918, p. 541-545. 6 half-tones, 16 plans, sections, etc. 1 fold. plate, with plan and sections.

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Harbor development in Australia. A. C. Mackenzie. (Com. E.), May 1, 1918, p. 293-297, incl. map, diagr. 1 fold. map.

Paper read by A. C. Mackenzie, Engineer of the Melbourne Harbor Trust, before the Institution of Municipal Engineers of Victoria.

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Champlain dry dock, Quebec. U. Valiquet. (Ca. E.), June 18, 1918, p. 529-535. 8 half-tones, 8 plans, sections, etc.

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HARBORS—FRANCE.

Condition at French ports during the war. A. Pawlowski. (Eng. C.), May 29, 1918, p. 540-541.

From "Le Génie Civil," Paris, Nov. 24, 1917.

Projects for the development of the port of Havre. (Eng. C.), May 29, 1918, p. 525-528. 2 half-tones.

Extract from "Le Genie Civil," Paris, Dec. 22, 1917.

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Les ports francais durant la guerre. Les ports de la Sousse et Sfax. A. Pawlowski. (Le Génie Civil), 1 juin, 1918, p. 389-393. 2 half-tones, 2 plans, 1 diagr., tables 3, 4.

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Les ports francais durant la guerre, Les ports de la Tunisie, I Bizerte et Tunis. A. Pawlowski. (Le Genie Civil), 25 mai, 1918, p. 369-375. 3 half-tones, 6 maps, tables; ii. Les ports de Sousse et Sfax, (Le Génie Civil), 1 juin, 1918, p. 389-392. 2 half-tone, 2 plans, 1 diagr., table.

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Les ports allemands de la mer Baltique. R. Bonnin. (La Nature, Paris), v. 43, 1er sem., no. 2, 162. 6 mars, 1915, p. 153-158. 2 half-tones, 6 maps.

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Les ports allemands de la Mer du Nord. R. Bonnin. (La Nature, Paris), v. 43, 1er sem., no. 2,164. 20 mars, 1915, p. 188-195. 5 half-tones, 5 maps, sketches, sections, etc.

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De bouw van de houtbereidings-inrichting en de beschoeiing langs de zeehaven te Dordrecht. F. W. Van Panthaleon baron Van Eck. (De Ing.), 6 april, 1918, p. 240-241. 1,850 words. 3 sections, 1 table.

Le port de Rotterdam. Victor Cambon. (La Nature, Paris), v. 43, 1er sem., no. 2,169, 24 avril, 1915, p. 265, 269. 4 half-tones, 1 map, 1 diagr.

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HARBORS—NORWAY.

Harbor improvement in Norway. (Commerce Reports), July 6, 1918, p. 72.

Report by Vice-consul H. E. Carlson, Christiania, May 15, 1918, on proposed improvements on the harbors of Berlevaag province Finmarken, Ramsund in Ofoten Islands, and Larvik Harbor,. the latter facing Kovkanalen, an arm of Larvik Bay.

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Boston and its port problem. (Freight H.), June, 1918, p. 208-211. 1 portrait.

A report on the port of Boston, by Prof. T. Chorington, of Harvard University, for the Boston Chamber of Commerce. Third installment, continued from January issue.

Why we will probably have some "Free Ports." (Business Digest), June 12, 1918, p. 777-778.

HIGHWAY BRIDGES.

Recent reinforced concrete highway bridge work in Ohio. (Eng. C.), June 26, 1918, p. 638-640. 6 half-tones.

Articles of Engineering Interest.

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Int.R.=Internationale Revue über die gesamten Armeen und Flotten, Dresden.

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W.S.E.J.=Western Society of Engineers. Chicago, Ill. Journal.

(Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 54, Nov.-Dec., 1918.)

AERIAL PHOTOGRAPHY.

Evolution de l'aviation allemande. v. Photographies aériennes. Par J. A. Lefranc, sous-lieutenant, breveté mécanicien adjoint technique. (La Nature), 46e année, 2e sémestre, no. 2341. 21 sept., 1918, p. [81]-90, incl. half-tones, maps, diagrs., sections.

Illustrations.—1. Spécimen de photo aérienne.—2. Plan directeur allemand (fragment)—3. Appareil photographique de 0,25 de foyer. Marque Ernemann 4. Appareil . . . de 0,50 de foyer. Marque Ica (1916)—5. Coupe schématique d'un appareil Goerz de 0,50 de foyer. 6. Comparison entre l'appareil allemand de 1,20 et celui de 0,50 de foyer (1918)—7. Schéma d'installation—8. Appareil chronophotographique—9. Magasin à films de l'appareil chronophotographique . . . —10. Schéma du magasin amovible porte-films de l'appareil chronophotographique—11. Commande mécanique R. M. V. A.—

BALLISTICS.

The long-range gun. Major J. Maitland-Addison, R. A. (J. R. Art.), July, 1918, p. 137-150. 6 large fold. plates (diagrs., etc.). With discussion.

Lecture delivered at the Royal Artillery Institution, 13 May, 1918. Brig. Gen. A. Stokes, . . . Comdg. the Troops, Woolwich, in the chair.

Contents.—The air resistance to projectiles—Diminution of atmospheric density as the altitude above the earth's surface increases.—The ballistic efficiency of a projectile.—Comparison of long range trajectories.—The trajectory of the long range gun.—The projectile.—The gun and its mounting.—The ultimate limit of velocity.—Summary.—Conclusion.

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Observation balloons. Lieut. Crivelli. (Field A. J.), July-Sept., 1918, p. 342-348.

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The first English electrically-welded barge. (Eng. C.), Oct. 30, 1918, p. 416. 2 half-tones. From "The Engineer."

COMMUNICATION AND TRAFFIC. See also CANALS—FRANCE.

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A crane hoist that is different. (Sci. Am.), Nov. 16, 1918, p. 396. 1 half-tone.

Novel craine hoist with a 10-foot boom built for the U. S. Marine Corps.

Some heavy fitting-out cranes.—1. Fixed cranes at Kearny and Hog Island Yards. (Eng. N.), Nov. 14, 1918, p. 885-889, incl. diagrs., sections, plans, etc.

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Manufacture of a new explosive in South Africa. By Vice Consul Chas. J. Pisar, Cape Town, Aug. 10, 1918. (Com. R.), Oct. 21, 1918, p. 282-283.

Treats on the new explosive known as "Sengite" which is to meet the growing shortage of nitroglycerin explosives, . . .

"Sengite," a new explosive. J. P. Udal. (Eng. M. J.), Nov. 9, 1918, p. 820.

From South African Journal of Industriee. Describes manufacture and application of a comparatively insensitive explosive, which may largely supersede ordinary nitroglycerin explosive for certain work.

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Portable garage solves problems of small truck users. (Com. Veh.), Sept. 15, 1918, p. 18-19, incl. 3 half-tones, 1 diagr.

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Cette, port franco-suisse. A. Pawlowski. (La Nature), 9 Feb., 1918, p. 93-95, incl. 3 half-tones.

Contemplated improvement of Loire basin. By Commercial Attaché Pierce C. Williams, Paris, France, Aug. 22, 1918. (Com. R.), Oct. 25, 1918, p. 341 344, incl. table.

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Les aggrandissements du port de Dunkerque. A. Breton. (La Nature), 5 Jan., 1918, p. 13-15, incl. map.

Les aggrandissements du port de La Pallice. (La Nature), 27 July, 1918, p. 31-32, incl. 1 map.

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Artillery information service. (Field A. J.), July-Sept., 1918, p. 349-362.

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U. S. Engineers bridge Marne with German equipment. R. K. Tomlin, Jr. (Eng. N.), Oct. 31, 1918, p. 798-799, 5 half-tones.

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Report of the Committee on standardization of flanges and pipe fittings. (Am. Soc. M. E.), Journal, Oct., 1918, p. 850-852, incl. 2 figs., tables 1-4.

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Refrigerating plant, intermediate depot for American army in France. R. K. Tomlin, Jr. (Power), Oct. 22, 1918, p. 596-598, 4 half-tones.

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An American gun that stops German tanks. (U. S. Nav. I.), Sept., 1918, p. 2128-2130, incl. 1 half-tone. From "Literary Digest."

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First unit of improved means of sewage disposal for Philadelphia well started. W. L. Stevenson. (Eng. N.), Oct. 3, 1918, p. 629-633, incl. diagr., sections.

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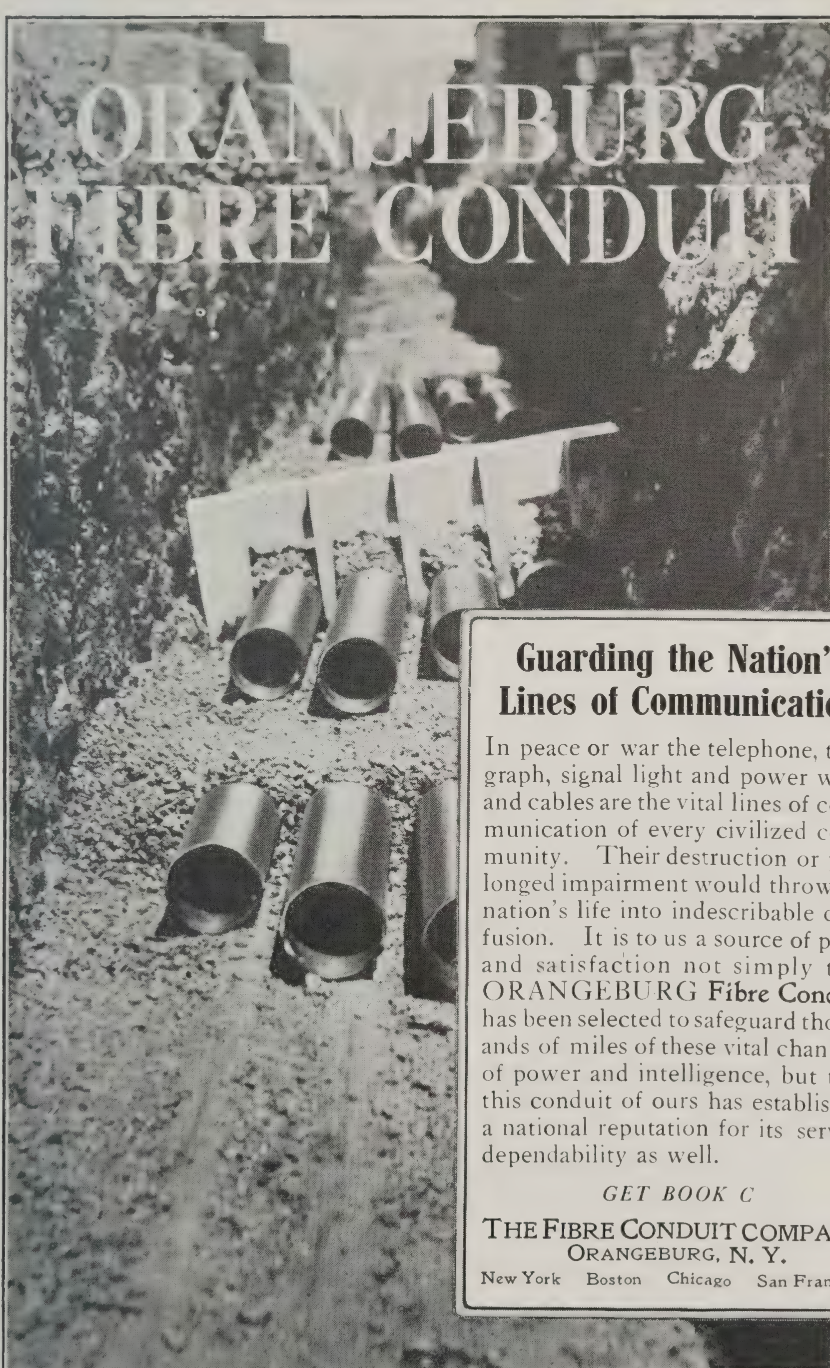

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R.U.S.I.J.=Royal United Service Institution, London. Journal.

Sci.Am.=Scientific American, N. Y.

Sci.Am.S.=Scientific American Supplement, N. Y.

Soc.Eng.=Society of Engineers, London. Transactions.

Tech. M.=La Technique Moderne, Paris.

U.S.Nav.I.=U. S. Naval Institute, Annapolis, Md. Proceedings.

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Prepared for PROFESSIONAL MEMOIRS, v. 10, No. 53, Sept.-Oct., 1918.

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Appareils photographiques des Zeppelins et des aviatiks. H. Perrotin. (La Nature, Paris), v. 43, per sem., no. 2168. 17 avril, 1915, p. 262. 3 half-tones. LC (Q2N2. v. 43-1).

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Illustrations—Assembling aerial photographs into a living map of the enemy's positions and back areas.

The photographic eye and memory of the military airman. (Sci. Am.), July 27, 1918, p. 61-76. 5 half-tones.

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Our sky army. C. Grey. (Sci. Am.), May 25, 1918, p. 479, 488. 1310 words.

What America can do to win the war in the air.

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Deals with a giant aeroplane brought down by the French on the night of June 1st-2d, near Nateuille-Haudoin, half-way between Soissons and Paris.

Les nouveaux types d' avions allemands et autrichiens. (Le Genie Civil), 15 juin, 1918; p. 429-434. 19 figs., 3 half-tones, 16 section, etc.

The present state of the German aviation program. E. H. Sherbondy. (Aerial Age Weekly), July 29, 1918, p. 961-965. Half-tones, diagrs, sections, etc.

Describes the Gotha, Fokker, Albatros, Rumpler, etc., etc., types.

Types of military aeroplanes. Col. V. E. Clark. (Sci. Am. S.), May 25, 1918, p. 322. 201 words.

The possibilities of the bomber.

AISNE, BATTLE OF THE, 1917—AILETTE. See under EUROPEAN WAR, 1914—CAMPAIGNS.

ANTI-AIRCRAFT FIRING.

General comment on anti-aircraft firing. Lieut. Col. Reille. (Field Art. Journal), April-June, 1918. Half-tone, facing page 250.

Author is head of Artillery in French Mission.

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Anti-aircraft truck mount, model 1917, for 75 mm. Field gun, model 1916, (Field Art. Journal), April-June, 1918. Half-tone, facing page 250.

Il proplema del tiro antiarro. G. Fioravanzo. (Rivista Marittima), Dic., 1917, p. 323-331. 6 figs.

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ARMY CANTONMENTS.

The building of Camp Devens, (New Eng. Water W. Assn.), Journal, June, 1918, p. 145-153.

A discussion by Messrs. Leonard Metcalf and George W. Fuller. The original article on Camp Devens, by Frank Barbour, will be published later, owing to the illness of author.

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The construction of Camp Devens. V. T. Goggin. (Conn. Soc. Civil Eng.), Papers, 1917, p. 68-79. 1 plan.

Porto Rico army camp designed for tropical conditions. (Eng. N.), July 11, 1918, p. 85-87. 4 half-tones.

Ideal side near San Juan in hills by ocean. Designs made more airy. Sanitary details raise standard in island territory.

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Small army warehouses built with speed and econemy. (Eng. N.), May 30, 1918, p. 1945-1947, 3 half-tones, plan, sections, etc.

One-story timber frame building for overseas shipments are of simple design which permitted rapid erection.

ARTILLERY.

The use and importance of artillery in modern warfare. Major C. J. C. Street. (Infantry Journal), July, 1918, p. 61-64.

ASPHYXIATING GAS.

Gas attack and liquid fire in modern warfare. (Sci. Am. S.), v. 85, March 23, 1918, p. 189.

La lutte cantre les vapeurs asphyxiactes. Drs. D. et O. (La Nature, Paris), v. 43, 1er sem., no. 2173, 22 mai, 1915, p. 335-340. 2 half-tones, 3 sections. LC (Q2N2, v. 43-1).

Fig. 1 . La confection des masques contre les vapeurs. Fig. 2. Le masque et son armature metallique.

ATTACK AND DEFENSE (MILITARY SCIENCE).

Shell holes. (R. Eng. J.), May, 1918, p. 240-242.

Translated from ''Revue Militaire Suisse,'' Jan. 1918.

. . . "Shell holes . . . have not only become a useful adjunct to a defensive system, but they are now even an essential and indispensable part of a fortified front" . . .

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Internal ballistics. Lieut. Col. A. G. Hadcock. (Eng.), May 31, 1918, p. 614-615; the same. (Eng.), June, 1918, p. 490.

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Long-range artillery calculation. Sir G. Greenhill. (Eng.), April 26, 1916, p. 464-465. 2510 words; The same, (Sci. Am. S.), June 8, 1918, p. 362. 2100 words.

BARGES. See also CONCRETE SHIPS.

The history of concrete barge and ship construction. J. E. Freeman. (Eng. C.), May 22, 1918, p. 505. 3148 words.

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Contains exhaustive reviews of important military treatises, written by military men of high standing.

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Blast-furnace "Bears." (Sci. Am. S.), July 13, 1918, p. 27.

Digest of a paper by Dr. J. E. Stead read before the Iron and Steel Institute, London.

BRIDGES. See also HIGHWAY BRIDGES—RAILROAD BRIDGES.

Don River bascule bridge, Toronto. G. T. Clark, (Ca. E.). May 23, 1918.

Toronto Harbor Commission erects single leaf Strauss Trunnion bascule over Don River at Cherry Street to accommodate the new "Eastern Harbor Terminal District." Some details of design and construction. 2,200 words. 2 half-tones, 1 plan, 3 cross-sections.

The longest possible bridge spans. (Sci. Am.), June 1, 1918, p. 504-511, 1638 words. 4 half-tones.

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The principal bridges of the world. A comparison. (Eng.), May 24, 1918, p. 441-442. 1 fold. plate, showing planes, elevation, sections, etc., ii. (Eng.), May 31, 1918, p. 463-464. Fold. plate, (sections, etc.). Continued from May 24, 1918.

Contents—Cantilever bridges—Steel viaducts.

The plate accompanying this article is reprinted in (Ca. E.), June 27, 1918; p. 574-575; July 4, 1918; p. 19, under title. Some of the principal bridges of the world compared.

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Contents—The new German scheme of defense—The English failure of the public to understand the event—Its reaction on the high command—The British conception of the western front—The artillery factor.

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Apparecchi fumigeni tedeschi. (R. Art. G.), Aprile maggio, 1918, p. 90-92. 3 outline figs.

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Camouflage in nature. 2d Lieut. W. C. Kiplinger, N. A. (Infantry Journal), July, 1918, p. 57-60.

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CANALS. See also INLAND NAVIGATION.

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Reasons why they hope to rival continental waterways.

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Concreting with compressed air, J. F. Springer, (Eng. C. W.), June 1, 1918, p. 13-16. 5 half-tones.

Placing concrete by compressed air in the key of the concrete lining inside the iron lining of the New York twin tunnels.

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Core construction, A. H. Bromley, jr., (Ca. E.), July 4, 1918, p. 9-11. 1 half-tone, 2 sections.

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A review of facts developed in recent discussions.

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The 7,500-ton vessels building, a torpedo may pierce two compartments without causing them to sink. Opinion of R. J. Wig, Chief of Concrete Ship Construction Dept., Emergency Fleet Corporation.

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Volcanic rock forms basis for concrete of high strength and weight twenty percent lighter than normal.

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Elevator conveyor for handling ship cargo. (Eng. C.), June 26, 1918, p. 652. I half-tone.

Describes the portable Donald elevator conveyor. It has been recently introduced in this country from England, and is designed for rapid loading and unloading of vessels.

The new gravity bucket conveyor of Messrs Fraser and Chalmers, Frith. G. F. Zimmer. (Eng.), June 28, 1918, p. 718. 4 sections.

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CRANES, HOISTS, Etc. See also CONVEYORS.

$31\frac{1}{2}$-ton locomotive steam crane. J. H. Wilson & Co., Lim. (Eng.), June 7, 1918, p. 634, 3 figs., half-tones, sections, etc.

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Good handling equipment speeds ore dock constrution. (Eng. N.), June 27, 1918, p. 1215-1216. 3 half-tones.

Pile-drivers make record. Concrete readily placed by floating plant. Standardized forms swung from movable derricks.

Tower derricks serve twin shipways at submarine boat corporation yard. (Eng. N.), June 6, 1918, p. 1073-1077. 3 half-tones, 5 plans, sections, etc.

Ships erected by 86-ft. booms on fixed towers between pairs of ways. Two booms per ship. Arrangement for greatest flexibility. Ships overhang narrow ways and scaffolds are built up from ground.

DAMS. See also CANALS-SWEDEN—IRRIGATION.

Design of a tiltng dam. V. B. Siems. (Ca. E.), July 25, 1918, p. 79-81. 1 half-tone.

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Reservoir dams. (Eng.), June 21, 1918, p. 687-688. 18 figs., half-tones, sections, et.

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Operation of Grand River roller dam proves satisfactory. S. O. Harper. (Eng. N.), June 27, 1918, p. 1225-1226. 1 half-tone, 1 detail drawing. Observations on behavior of largest of the three.

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Northern-Pacific structure has frame resting on wood piles and sand filled cribs—Detail differences from other designs.

DRY DOCKS.

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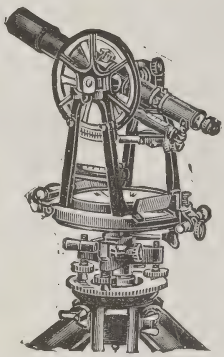

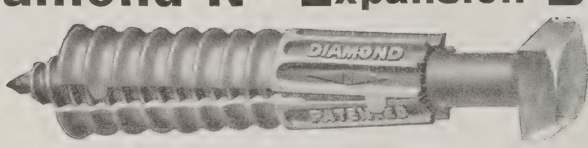
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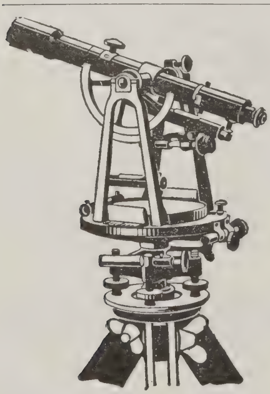


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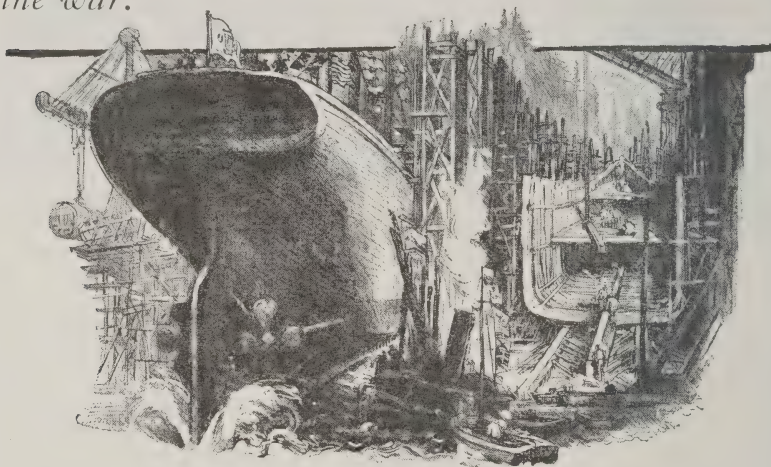

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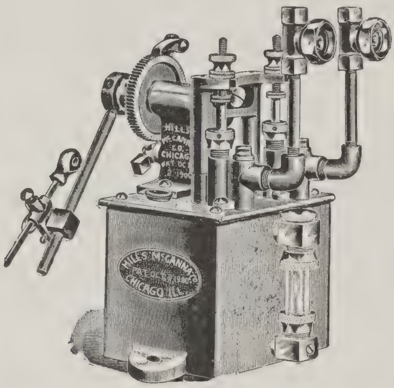

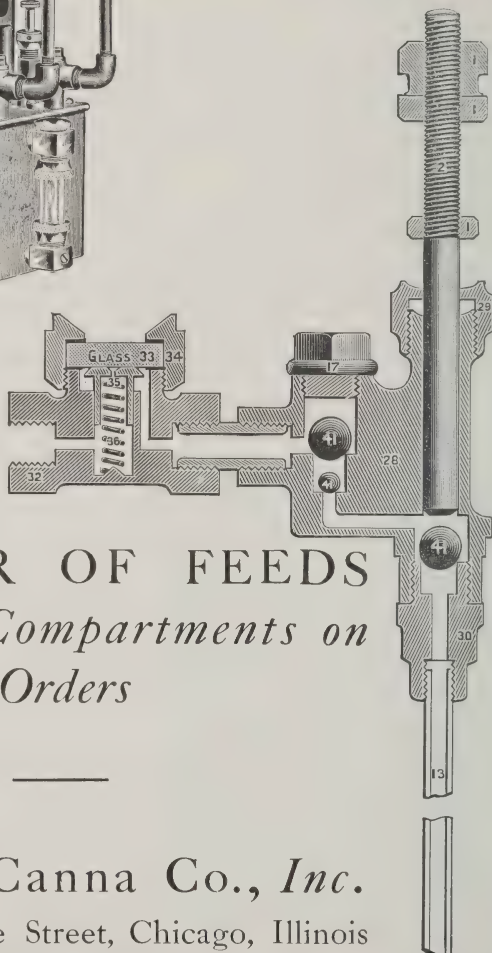

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